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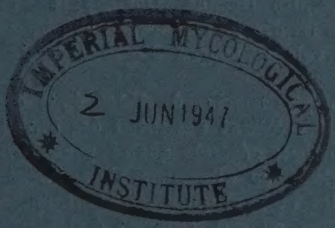

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№ 2

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MATHEMATIK

ÜBER DAS LOGARITHMISCH NORMALE VERTEILUNGSGESETZ DER DIMENSIONEN DER TEILCHEN BEI ZERSTÜCKELUNG

Von A. N. KOLMOGOROFF, Mitglied der Akademie

In einer kürzlich erschienenen Note von N. Rasumovski (1) werden viele Fälle angeführt, in denen die Logarithmen der Dimensionen der Teilchen (Goldkörner im Goldsand, Erzklumpen bei ihrer Zerstückelung, usw.) annähernd dem Gausschen Verteilungsgesetz genügen. Das Ziel der vorliegenden Note ist es, hierzu ein allgemeines Schema des zufälligen Prozesses der schrittweisen Zerstückelung von Teilchen anzugeben, für das das Gaussche Verteilungsgesetz für die Logarithmen der Dimensionen der Teilchen im Grenzwert (bei unbeschränkter Verfeinerung) theoretisch abgeleitet werden kann. Möglicherweise können ähnliche Betrachtungen auch zu einer Erklärung der Anwendbarkeit der Gausschen Verteilung auf die Logarithmen des Erzgehalts in einzelnen Proben führen (dieser Fragestellung ist, im wesentlichen, die erwähnte Note von N. Rasumovski gewidmet).

Wir betrachten die Gesamtanzahl der Teilchen $N(t)$ und ihre Verteilung nach Dimensionen in nacheinander folgenden Momenten $t=0, 1, 2, 3, \ldots$

Es bezeichne $N(r, t)$ die Anzahl der Teilchen mit den Dimensionen $\rho \leqslant r$ zur Zeit t (für das folgende ist es unwesentlich, was hierbei ρ bedeutet: den Durchmesser, das Gewicht, oder irgendeine andere Charakteristik der Dimension des Teilchens, wenn nur die Bedingung erfüllt ist, dass die Dimension jedes Teilchens, das infolge der Zerstückelung eines Teilchens von Dimension r entstanden ist, r nicht übertrifft). Wir bezeichnen mit $Q(k)$ die mathematische Erwartung der Anzahl der Teilchen von Dimensionen $\rho \leqslant kr$, die in der Zeit zwischen t und $t+1$ aus einem Teilchen entstehen, das zur Zeit t die Dimension r hatte, und setzen

$$A = \frac{1}{Q(1)} \int_0^1 \log k \, dQ(k). \tag{1}$$

$$B^2 = \frac{1}{Q(1)} \int_0^1 (\log k - A)^2 \, dQ(k). \tag{2}$$

Unter einigen, weiter unten aufgezählten, Annahmen kann gezeigt werden, dass das Verhältnis

$$\frac{N(e^x, t)}{N(t)} \tag{3}$$

für genügend grosse t mit einer zu Eins beliebig nahen Wahrscheinlichkeit sich beliebig wenig von

$$\frac{1}{\sqrt{2\pi t}\, B} \int_{-\infty}^{x} e^{-\frac{(\xi - At)^2}{2B^2 t}} d\xi \tag{4}$$

unterscheiden wird. Die wesentlichste Annahme, die wir zum Beweis dieser Beziehung machen, besteht in der Unabhängigkeit der Wahrscheinlichkeiten dafür, dass jedes Teilchen in der Zeiteinheit zu einer oder anderen Anzahl von Teilen zerstückelt wird, deren Dimensionen zu der absoluten Dimension des Teilchens in diesem oder jenem Verhältnis stehen.

Um unsere Annahmen genauer formulieren zu können, führen wir einige Bezeichnungen ein. Es sei p_n die Wahrscheinlichkeit, in der Zeit zwischen t und $t+1$ bei Zerstückelung eines Teilchens genau n Teilchen zu erhalten, und

$$F_n(a_1, a_2, \ldots, a_n) = P(k_1 \leqslant a_1,\ k_2 \leqslant a_2,\ \ldots,\ k_n \leqslant a_n)$$

das relative Verteilungsgesetzt der Verhältnisse $k_i = \frac{r_i}{r}$ der Dimensionen der hierbei erhaltenen n Teilchen zu der Dimension des Ausgangsteilchens. Die Numeration der n Teilchen, die bei der Zerstückelung entstehen, werden wir nach den wachsenden Dimensionen $r_1 \leqslant r_2 \leqslant r_3 \leqslant \ldots \leqslant r_n$ vornehmen. Entsprechend ist die Funktion $F_n(a_1, a_2, \ldots, a_n)$ nur für

$$0 \leqslant a_1 \leqslant a_2 \leqslant \ldots \leqslant a_n \leqslant 1$$

definiert. Offenbar haben wir

$$Q(k) = \sum_{n=1}^{\infty} P_n \{F_n(k, 1, \ldots, 1, 1) + F_n(k, k, 1, \ldots, 1, 1) + \ldots + F_n(k, k, k, \ldots, k, 1) + F_n(k, k, \ldots, k, k)\}.$$

Wir nehmen an, dass

a) die Wahrscheinlichkeiten P_n und die Verteilungen F_n von den absoluten Dimensionen des Teilchens, seiner Vorgeschichte (d. h. der vorhergehenden Zerstückelungen, die zum Entstehen dieses Teilchens führten) und des Schicksales anderer Teilchen nicht abhängen;

b) die mathematische Erwartung $Q(1)$ der Gesamtanzahl der Teilchen, die in der Zeit zwischen t und $t+1$ aus einem Teilchen entstehen, endlich und grösser als Eins ist;

c) das Integral

$$\int_0^1 |\log k|^3 \, dQ(k) \tag{5}$$

endlich ist;

d) im Anfangsmoment $t=0$ eine bestimmte Anzahl von Teilchen $N(0)$ mit einer beliebigen Verteilung nach Dimensionen $N(r, 0)$ vorhanden ist.

Unter diesen Annahmen gilt:

1) die mathematische Erwartung der Gesamtanzahl $N(t)$ der Teilchen zur Zeit t ist gleich

$$\overline{N}(t) = N(0)\, Q^t(1); \tag{6}$$

2) das Verhältnis (4) unterscheidet sich für genügend grosse t mit einer zu Eins beliebig nahen Wahrscheinlichkeit beliebig wenig von dem Verhältnis

$$\frac{\overline{N}(e^x, t)}{\overline{N}(t)} = \frac{\overline{N}(e^x, t)}{N(0)\, Q^t(1)} = T(x, t) \tag{7}$$

der entsprechenden mathematischen Erwartungen *.

---

* Man soll diesen Umstand nicht als ganz offenbar betrachten. Für die Grössen $N(t)$ und $N(r, t)$, einzeln genommen, ist die analoge Behauptung über ihre asymptotische Annäherung gegen die Erwartungen, $\overline{N}(t)$ und $\overline{N}(r, t)$, falsch.

Somit besteht unsere Aufgabe in der Abschätzung von $T(x,t)$. Aus den Annahmen a) und b) folgt, dass

$$\overline{N}(r, t+1) = \int_0^1 \overline{N}\left(\frac{r}{k}, t\right) dQ(k). \tag{8}$$

Setzen wir

$$Q(k) = Q(1)\, S(\log k), \tag{9}$$

so erhalten wir aus (7) und (8)

$$T(x, t+1) = \int_{-\infty}^{0} T(x-\xi, t)\, dS(\xi). \tag{10}$$

Aus (7) und (9) folgt leicht, dass die Funktionen $S(x)$ und

$$T(x, 0) = \frac{N(e^x, 0)}{N(0)}$$

allen Bedingungen genügen, die von Verteilungsfunktionen verlangt werden müssen *. Infolge der Rekurrenzbeziehung (10) gilt dasselbe auch in bezug auf die Funktionen $T(x,t)$ für beliebige ganze $t > 0$ **.

Aus der Bedingung c) folgt, dass das Integral

$$\int_{-\infty}^{0} |x|^3\, dS(x) \tag{11}$$

endlich ist. Infolge von (10) und (11) haben wir nach dem Satz von Liapounoff für $t \to \infty$

$$T(x,t) \to \frac{1}{\sqrt{2\pi t}\, B} \int_{-\infty}^{x} e^{-\frac{(\xi - At)^2}{2B^2 t}} d\xi \tag{12}$$

gleichmässig bezüglich x, wo $A = \int_{-\infty}^{0} x\, dS(x)$, $\quad B^2 = \int_{-\infty}^{0} (x-A)^2\, dS(x)$

offenbar mit den durch die Formeln (1) und (2) definierten Grössen zusammenfallen.

Es wäre interessant, die mathematischen Schemen zu untersuchen, in denen die Geschwindigkeit der Zerstückelung der Teilchen mit der Verkleinerung ihrer Dimensionen abnimmt (oder zunimmt). Es ist dabei naturgemäss in erster Linie diejenigen Fälle zu betrachten, in denen die Geschwindigkeit der Zerstückelung einer Potenz der Dimensionen der Teilchen proportional ist. Wenn diese Potenz von Null verschieden ist, so ist es anzunehmen, dass das logarithmisch normale Gesetz nicht mehr anwendbar sein wird.

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ZITIERTE LITERATUR

[1] N. Rasumovski, C. R. Acad. Sci. URSS, XXVIII, 815 (1940).

Übersetzt von V. Levin.

* Dabei ist für $x>0$ $S(x)=S(0)=1$. Daher kann in allen Integralen mit dS die obere Grenze 0 ohne Änderung des Integralswerts durch ∞ ersetzt werden.

** In unserem Problem sind $S(x)$ und $T(x,t)$ nicht Wahrscheinlichkeitsverteilungen, sondern bedeuten bestimmte mathematische Erwartungen. Dies stört aber nicht der Anwendung auf sie des Satzes von Liapounoff, die als ein Satz der Analyse betrachtet wird.

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MATHÉMATIQUES

SUR LA DÉFINITION D'UNE FONCTION HARMONIQUE

Par I. I. PRIVALOFF, membre correspondant de l'Académie

Théorème 1. *Si $u(Q)$ est une fonction continue dans un domaine G et si elle vérifie la condition $\underline{\Delta}^* u(Q) \leqslant 0 \leqslant \overline{\Delta}^* u(Q)$ en chaque point de ce domaine, sauf peut être aux points d'un ensemble E de mesure nulle, alors cette fonction est harmonique dans le domaine G, pourvu que l'on ait $\overline{\Delta}^* u(Q) > -\infty$, $\underline{\Delta}^* u(Q) < +\infty$ partout dans le domaine G, sauf peut être aux points d'un ensemble fermé E_1 de capacité nulle.*

Dans cette proposition $\underline{\Delta}^* u(Q)$ et $\overline{\Delta}^* u(Q)$ désignent, respectivement, l'opérateur de Laplace généralisé inférieur et supérieur, déterminés ou bien en prenant la moyenne de la fonction pour le volume d'une sphère ayant pour centre le point Q, ou bien la moyenne pour la surface d'une sphère de centre Q [1]. La démonstration de ce théorème résulte de la proposition auxiliaire suivante:

Lemme. *Si une fonction $u(Q)$ continue dans un domaine G vérifie la condition $\overline{\Delta}^* u(Q) \geqslant 0$ en chaque point Q de ce domaine, sauf peut être aux points d'un ensemble E de mesure nulle, alors cette fonction est subharmonique dans le domaine G, pourvu que l'on ait $\overline{\Delta}^* u(Q) > -\infty$ partout dans le domaine G, sauf peut être aux points d'un ensemble fermé E_1 de capacité nulle.*

Démonstration. En supposant que la fonction $u(Q)$ vérifiant les conditions du lemme n'est pas subharmonique dans le domaine G, nous aboutissons à une contradiction. En effet, il existe dans ce cas un domaine D, $\overline{D} \subset G$, et une fonction $U(Q)$ harmonique à l'intérieur de D et continue dans $\overline{D}$, tels que les conditions suivantes sont remplies:

$$u(Q) \leqslant U(Q) \tag{1}$$

à la frontière Γ du domaine D, tandis qu'à l'intérieur de D on a partout ou dans un certain domaine

$$u(Q) > U(Q). \tag{2}$$

Supposons que l'inégalité (2) est remplie dans le domaine $d \subset D$. Construisons une couche non négative $\mu(e)$ de la manière suivante. Enfermons l'ensemble E de mesure nulle en un système dénombrable de domaines α, dont la somme des volumes est inférieure à ε_1, ensuite en un système de domaines β, dont la somme des volumes est inférieure à ε_2, etc., la série $\varepsilon_1 + \varepsilon_2 + \ldots$ étant supposée convergente. Prenons $\mu(e)$ égale à la somme des volumes $\alpha, \beta, \ldots$ et de leurs parties appartenant à e. La fonction d'ensemble $\mu(e)$ ainsi construite aura en chaque point de l'ensemble E une dérivée symétrique égale à $+\infty$. Formons maintenant la fonction subharmonique correspondante $f(Q) = -\int_D g(P; Q)\, d\mu(e)$, qui doit vérifier les conditions suivantes:

a) $\overline{\Delta}^* f(Q) = +\infty$ aux points de l'ensemble E, parce qu'en ces points la loi de distribution $\mu(e)$ a une densité égale à $+\infty$ [2];

b) $\overline{\Delta}^* f(Q) \geqslant 0$ partout dans le domaine D, parce que $f(Q)$ est subharmonique.

En choisissant un point Q_1 du domaine d, hors de l'ensemble E_1, où la valeur $f(Q_1)$ est finie, considérons une fonction auxiliaire $F(Q) = u(Q) + \varepsilon f(Q)$, et en choisissant le nombre ε nous pouvons obtenir au point Q_1 l'inégalité

$$F(Q_1) > U(Q_1); \tag{3}$$

ceci est possible en vertu de (2).

Comme sur la frontière Γ on a l'inégalité (1), il en résulte que $F(Q) \leqslant U(Q)$ sur Γ, où l'on prend pour $F(Q)$ aux points de Γ les limites supérieures de ses valeurs quand on s'approche de la frontière en restant à l'intérieur de D.

Remarquons, d'ailleurs, que $F(Q)$ est semicontinue supérieurement dans le domaine $\overline{D}$. Il est évident que $\overline{\Delta}^* F(Q)$ ne peut être $\geqslant 0$ partout dans le domaine D, car dans ce cas la fonction $F(Q)$ serait subharmonique; donc, l'inégalité $F(Q) \leqslant U(Q)$, qui a lieu sur la frontière du domaine D, serait aussi vraie à l'intérieur de D, ce qui est impossible en vertu de l'inégalité (3). D'autre part, l'opérateur généralisé $\overline{\Delta}^* F(Q)$ ne peut être négatif qu'aux points de l'ensemble E, parce que hors de E on a $\overline{\Delta}^* u(Q) \geqslant 0$, $\overline{\Delta}^* f(Q) \geqslant 0$. Or, aux points de l'ensemble E n'appartenant pas à E_1 on aura $\overline{\Delta}^* u(Q) > -\infty$, $\overline{\Delta}^* f(Q) = +\infty$; donc, en ces points $\overline{\Delta}^* F(Q) > 0$.

Donc, $\overline{\Delta}^* F(Q) \geqslant 0$ partout dans le domaine D, sauf peut être aux points d'un ensemble E_1 de capacité nulle. Par conséquent, la fonction $F(Q)$, semicontinue supérieurement dans le domaine D, est subharmonique à l'extérieur d'un ensemble E_1 de capacité nulle, donc, en vertu d'un théorème connu [3] $F(Q)$ doit être subharmonique partout dans le domaine D, ce qui est impossible en vertu de l'inégalité (3). En tenant compte du lemme démontré, on peut aussi démontrer le théorème suivant.

Théorème 2. *Deux fonctions continues $F_1(Q)$ et $F_2(Q)$, dont les opérateurs généralisés supérieurs de Laplace sont partout finis, sauf peut être aux points d'un ensemble fermé de capacité nulle, et presque partout égaux, ne peuvent différer que par une fonction harmonique.*

En effet $$\overline{\Delta}^*(F_1 - F_2) \geqslant \overline{\Delta}^* F - \overline{\Delta}^* F_2 > -\infty$$

partout dans le domaine G, sauf aux points d'un ensemble fermé E_1 de capacité nulle. D'autre part, il suit de la première partie de cette inégalité que $\overline{\Delta}^*(F_1 - F_2) \geqslant 0$ presque partout dans le domaine G. Il résulte du lemme que $F_1 - F_2$ doit être subharmonique dans le domaine G. En répétant ces raisonnements pour la fonction $F_2 - F_1$, nous verrons qu'elle est aussi subharmonique dans le domaine G. Donc, les fonctions $F_1 - F_2$ et $F_2 - F_1$ en étant subharmoniques et de signes contraires doivent être harmoniques.

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LITTÉRATURE CITÉE

[1] I. Privaloff, Rec. Math. (1925); И. И. Привалов, Субгармонические функции, 17 (1937). [2] S. Saks, Rec. Math. (1941); I. I. Privaloff, ibid. (1941). [3] Brelot, Etude des fonctions sousharmoniques au voisinage d'un point (1934); I. I. Privaloff, Rec. Math. (1938).

Traduit par N. Bary.

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MATHÉMATIQUES

QUELQUES APPLICATIONS DE L'OPÉRATEUR GÉNÉRALISÉ DE LAPLACE

Par I. I. PRIVALOFF, membre correspondant de l'Académie

Théorème 1. *Si $u(Q)$ est une fonction subharmonique dans un domaine G de l'espace à p dimensions, on a en chaque point Q_0 de ce domaine les inégalités* (2):

$$\underline{\rho}(Q_0) \leqslant \underline{\Delta}^* u(Q_0) \leqslant \overline{\Delta}^* u(Q_0) \leqslant \overline{\rho}(Q_0). \qquad (A)$$

Dans cette proposition $\underline{\Delta}^* u(Q_0)$ et $\overline{\Delta}^* u(Q_0)$ désignent, respectivement, les opérateurs généralisés de Laplace (1) inférieur et supérieur pour la fonction subharmonique $u(Q)$ au point Q_0, et $\underline{\rho}(Q_0)$ et $\overline{\rho}(Q_0)$ — les densités symétriques inférieure et supérieure au point Q_0 pour la distribution des masses qui correspondent à cette fonction.

Les inégalités (A) peuvent être appliquées à la démonstration des propositions suivantes.

Théorème 2. *Si deux fonctions $u(Q)$ et $v(Q)$ subharmoniques dans un domaine G vérifient les conditions*

a) $\underline{\Delta}^* u(Q) < +\infty$, $\underline{\Delta}^* v(Q) < +\infty$ *en chaque point du domaine G,*

b) $\overline{\Delta}^* u(Q) = \overline{\Delta}^* v(Q)$ *presque partout dans le domaine G, alors* $u(Q) = v(Q) + h(Q)$, *où $h(Q)$ est une fonction harmonique.*

Théorème 3. *Si E est un ensemble borné et fermé de mesure nulle, alors chaque fonction $u(Q)$, qui est au voisinage de E, uniforme, bornée supérieurement et subharmonique, doit nécessairement être subharmonique dans un domaine G contenant E, pourvu que $\overline{\Delta}^* u(Q_0) > -\infty$ partout sur E, sauf peut être aux points d'un ensemble fermé E_1 de capacité nulle.*

En formant $\overline{\Delta}^* u(Q_0)$, on prend pour valeur de la fonction au point Q_0 de l'ensemble E la limite supérieure des valeurs de $u(Q)$, quand Q tend vers Q_0 d'une manière quelconque.

On obtient du théorème 3 le corrolaire suivant: Si E est un ensemble borné et fermé de mesure nulle, alors chaque fonction $u(Q)$ uniforme, bornée et harmonique dans le voisinage de E sera nécessairement harmonique dans le domaine contenant E pourvu que

$$\overline{\Delta}^* u(Q_0) > -\infty, \quad \underline{\Delta}^* u(Q_0) < +\infty$$

partout sur E, sauf peut être aux points d'un ensemble fermé E_1 de capacité nulle.

En formant $\overline{\Delta}^* u(Q_0)$ et $\underline{\Delta}^* u(Q_0)$ on prend pour valeur de la fonction au point Q_0 de l'ensemble E respectivement les limites supérieure et inférieure des valeurs de $u(Q)$, quand le point Q tend vers Q_0 d'une manière quelconque.

Dans ce qui précède l'opérateur de Laplace généralisé peut être défini ou bien au moyen de la valeur moyenne de la fonction pour le volume d'une sphère ou bien au moyen de la valeur moyenne étendue à la surface d'une sphère.

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LITTÉRATURE CITÉE

[1] S. Saks, Rec. Math. (1941); I. I. Privaloff, ibid. (1941). [2] I. Privaloff, ibid. (1925); И. И. Привалов, Субгармонические функции, 17 и 140 (1937).

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ASTROPHYSICS

ON THE STABILITY OF EMDEN'S COMPRESSIBLE HETEROGENEOUS SPHERES

By A. B. SEVERNY

(Communicated by B. G. Fessenkoff, Member of the Academy, 24.I.1941)

In our previous note (1) we discussed the relative stability of Emden's spheres while in the state of hydrostatic equilibrium. The study was based on variational equations, whereby the perturbations considered were restricted by the condition that the radial symmetry of the sphere structure should be conserved. The results obtained were as follows: any Emden's sphere with a polytrope index $n < 3$ is stable, any sphere with $n = 3$ is in neutral equilibrium, whereas any sphere with $n > 3$ is unstable.

In the present note no such condition is imposed, and the variational equations used in studying the stability of Emden's spheres involve arbitrary perturbations. The equations of small motion near the equilibrium position in polar co-ordinates (r, θ, φ) are:

$$\frac{\partial^2 u}{\partial t^2} = \frac{\partial \chi}{\partial r}; \tag{I}$$

$$\frac{\partial^2 v}{\partial t^2} = \frac{1}{r^2}\frac{\partial \chi}{\partial \theta}; \quad \frac{\partial^2 w}{\partial t^2} = \frac{1}{r^2 \sin^2 \theta}\frac{\partial \chi}{\partial \varphi} \tag{1}$$

where u, v, w are the perturbations of corresponding polar co-ordinates at the point (r, θ, φ), while

$$\chi = U' - \frac{dp_0}{d\rho_0}\sigma \tag{2}$$

where U' is the perturbation of the gravitational potential; p_0, pressure; ρ_0, density; σ, condensation. From equations (1) it follows that

$$\frac{\partial^2}{\partial t^2}\left\{\Delta - \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 u)\right\} = \nabla^2\chi - \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial \chi}{\partial r}\right) \tag{II}$$

where

$$\Delta = \operatorname{div}(u, v, w) = -\sigma - \frac{1}{\rho_0}\frac{\partial \rho_0}{\partial r}u \tag{3}$$

in virtue of the continuity equation. (I) and (II) are the fundamental equations. It can easily be shown that, in virtue of Poisson's equation for U', both these equations are reduced to equation

$$\frac{\partial^2 \sigma}{\partial t^2} = 4\pi G\rho_0\sigma + \nabla^2\left(\frac{dp_0}{d\rho_0}\sigma\right) - \frac{1}{\rho_0}(\operatorname{grad}\rho_0, \operatorname{grad}\chi) \tag{4}$$

which we have recently suggested (²). (I) and (II) admit of the following solutions:

$$u=\sum_{l=0}^{\infty}A_l(r)\,S_l(\theta,\varphi)\,e^{i\sqrt{\lambda_l}t};\quad \Delta=\sum_{l=0}^{\infty}B_l(r)\,S_l(\theta,\varphi)\,e^{i\sqrt{\lambda_l}t} \tag{5}$$

where A and B depend on r only, S_l is a spherical harmonic of the order l, λ_l are parameters (characteristic numbers). Then for each l we obtain, instead of (I) and (II), equations for A and B (omitting the sign l):

$$-\lambda A=\frac{dF}{dr};\quad \lambda\left\{B-\frac{1}{r^2}\frac{d}{dr}(r^2A)\right\}=\frac{l(l+1)}{r^2}F \tag{6}$$

where, according to (2) and (3)

$$F=V_0+\frac{A}{\rho_0}\frac{d\rho_0}{dr}+B\frac{d\rho_0}{d\rho_0} \tag{7}$$

while V_0, the perturbation «amplitude» of the gravitational potential, is (³)

$$V_0=-\frac{4\pi G}{(2l+1)r^{l+1}}\int_0^r\left(A\frac{d\rho_0}{dr}+B\rho_0\right)r^{l+2}\,dr-$$

$$-\frac{4\pi G r^l}{2l+1}\int_r^a\left(A\frac{d\rho_0}{dr}+B\rho_0\right)\frac{dr}{r^{l-1}}. \tag{8}$$

The particular case when $l=0$ corresponds to radially symmetrical perturbations. It can easily be seen that in this case the problem of the study of characteristic numbers is identical with that discussed in the previous note (¹). We shall, therefore, confine ourselves to the case $l\geqslant 1$. From the consideration of the system (6) it can be concluded with the aid of (7) and (8) that the existence of a non-trivial solution of equation

$$\frac{d^2u_1}{dr^2}-\frac{l(l+1)}{r^2}u_1=-\frac{4\pi G\rho_0}{\frac{dp_0}{d\rho_0}}u_1 \tag{9}$$

under the conditions

$$u_1(0)=0,\quad\left[\frac{du_1}{dr}+\frac{l}{r}u_1\right]_{r=a}=0 \tag{10}$$

is necessary and sufficient for the existence, with a given l, of a characteristic number equal to zero, or for the existence of a bifurcation in the «vibration» of the order l; u_1 denotes here

$$u_1=\frac{r}{\rho_0}\frac{dp_0}{d\rho_0}\left(A\frac{d\rho_0}{dr}+B\rho_0\right) \tag{11}$$

while a denotes the radius of the sphere. Let us point out the following general property which becomes evident from a consideration of system (9), (10): if there is no bifurcation in vibration l', there will surely be none in any of the $l>l'$ vibrations.

Passing to Emden's spheres, let us first discuss the particular case when the relative change of density σ is finite at the boundary of the sphere, where the density vanishes. Then, if we pass to Emden's variables (¹) with $l=1$, equation (9) will be

$$\frac{d^2u_1}{d\xi^2}+\left(n\vartheta^{n-1}-\frac{2}{\xi^2}\right)u_1=0 \tag{12}$$

while instead of the conditions (10) we shall have

$$u_1(0)=u_1(\xi_0)=0 \tag{13}$$

where ξ_0 is the first root of Emden's function θ fixing the boundary of the sphere; thus, the problem is reduced to a study of oscillations in the solution of (12) within a closed interval $(0, \xi_0)$. With $n=0$ (stable, homogeneous, incompressible sphere), the solution of equation (12), under condition that $u_1(0)=0$, does not oscillate in $(0 \leqslant \xi \leqslant \xi_0)$. With the increase of n function

$$Q_n \equiv n\theta^{n-1} - \frac{2}{\xi^2}$$

increases in all points $(0, \xi_0)$ and bifurcation is likely to take place. It may easily be shown that with any $n \leqslant 1$, the function u oscillates less rapidly than function $u_1^* = \xi^2\theta^n$. Consequently, there are no bifurcations for Emden's spheres $0 \leqslant n \leqslant 1$. Further, with $n > 1$

$$Q_n \leqslant n - \frac{2}{\xi^2}$$

and the solution u_1 oscillates also less rapidly than function $\sqrt{\xi}\, J_{3/2}(\sqrt{n}\xi)$, where $J_{3/2}$ is Bessel's function of the order 3/2. The least positive root of this function of comparison is $\xi' = 4.522.../\sqrt{n}$. As for Emden's spheres with index n within the range $1 \leqslant n \leqslant \frac{3}{2}$, ξ_0 changes from π to 3.6571 respectively, these spheres have no bifurcations, either. Emden's spheres with $n > \frac{3}{2}$ require numerical integration of equation (12). We carried it out for $n=3$ and obtained that in this case, too, there are no zeros for u_1 in the closed interval $(0, \xi_0)$ (besides $\xi=0$). Since for any sphere n within the limits of $\frac{3}{2} \leqslant n \leqslant 3$, function $Q_n \leqslant Q_3$, there is no bifurcation for any of these spheres, either. In so far as the sphere $n=0$ is stable, and we have found no change of stabilities to take place if n is changed from 0 to 3, any Emden's sphere with an index of polytrope $n \leqslant 3$ is stable towards perturbations $l=1$, and, consequently, towards any perturbation $l > 1$.

An analogous study was carried out also for the general case, when the boundary conditions have the form (10). In this case we obtain that for each n within the same limits there are no non-trivial solutions of (12) vanishing at $\xi=0$, and such that equation $u_1'(\xi) + \frac{2}{\xi} u_1(\xi) = 0$ has roots within the interval $(0, \xi_0)$ closed from the right side. Thus, making use of the results obtained in our previous article ([1]), we arrive at the following conclusions: 1) any Emden's sphere with $n < 3$ is stable with regard to any vibration ($l = 0, 1, 2, \ldots$) or is stable in general (according to variational equations); 2) sphere $n=3$ is in neutral equilibrium with regard to purely radial vibrations ($l=0$) and stable with regard to any vibration $l \geqslant 1$; 3) Emden's spheres with $n > 3$ are unstable; the question as to the store of stability of these spheres with $n > 3$ with respect to perturbations $l \geqslant 1$ is of minor importance, and has not been discussed by us.

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REFERENCES

[1] A. B. Severny, C. R. Acad. Sci. URSS, XXX, No. 5 (1941). [2] А. Б. Северный, Тр. гос. астр. ин-та им. Штернберга, XIII, вып. 2 (1940). [3] J. H. Jeans, Phil. Trans. (A), **199**, 1 (1902).

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ASTROPHYSICS

ON THE STABILITY OF GASEOUS STARS AND WHITE DWARFS

By A. B. SEVERNY

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In the present note there is discussed the problem of the stability of a non-rotating spherical star when in the state of hydrostatic equilibrium. The stability is studied with the aid of variational equations for such perturbations which do not affect the spherical symmetry of the star, and under the assumption that in its disturbed state of motion, the star is no dissipative system. In other words, the effect of the viscosity of the star substance in motion, as well as that of irreversible heat generation, have been left by us out of consideration (the so-called «adiabatic approximation»). This simplification is not essential, since the effect of both these factors on the estimation of stability has already been discussed by Rosseland (1). As to the stability itself, no study of the «adiabatic approximation» has been made for stars, be it on the base of most general assumptions as to their structure.

The problem formulated above may be reduced to the study of the characteristic numbers λ of equation (1)

$$\frac{d}{dr}\left\{\gamma p_0 \frac{1}{r^2}\frac{d}{dr}\left(r^2\xi\right)\right\}+\frac{d}{dr}\left\{(1-\mu)\,\rho_0 g_0 \xi\right\}+\frac{4g_0\rho_0}{r}\xi=-\rho_0\lambda\xi$$

where p_0 is total pressure (equal to the sum of gas pressures and radiation); ρ_0, density; g_0, acceleration of gravity; ξ, «amplitude» of radial displacement of particles from the position of equilibrium, while γ and μ are:

$$\gamma=\frac{\rho_0}{p_0}\left(\frac{\partial p_0}{\partial \rho_0}-\frac{\partial \varepsilon_0}{\partial \rho_0}\frac{\partial p_0}{\partial T_0}\frac{1}{\dfrac{\partial \varepsilon_0}{\partial T_0}}\right)+\frac{\partial p_0}{\partial T_0}\frac{1}{\dfrac{\partial \varepsilon_0}{\partial T_0}}\left(1+\frac{\varepsilon_0}{p_0}\right),$$

$$\mu=\frac{\partial p_0}{\partial T_0}\frac{1}{\dfrac{\partial \varepsilon_0}{\partial T_0}}\left\{\frac{\partial \varepsilon_0}{\partial p_0}+\frac{\partial \rho_0}{\partial p_0}\left(\frac{\partial \varepsilon_0}{\partial T_0}\frac{1}{\dfrac{\partial p_0}{\partial T_0}}\frac{\partial p_0}{\partial \rho_0}-\frac{\partial \varepsilon_0}{\partial \rho_0}\right)\right\}.$$

All these values in general are certain functions of r, distance from the centre of the sphere (ε_0 is the density of energy of gas and radiation together, T_0 — temperature). Function ξ will be considered as finite and continuous throughout the star. Let us consider a star consisting entirely of perfect gas with a constant relation of specific heats $\Gamma=\frac{c_p}{c_v}$ and a constant molecular weight. Then

$$\varepsilon_0=\frac{1}{\Gamma-1}R\rho_0T_0+aT_0^4\equiv\frac{1}{\Gamma-1}p_G+3p_R,\quad p_0=R\rho_0T_0+\frac{1}{3}aT_0^4\equiv p_G+p_R;$$

let us define γ and μ for a star in a radiative equilibrium. Introducing the variable relation β of the gas pressure p_G to total pressure p_0, we have $p_G=\beta p_0$, $\quad p_R=(1-\beta)\,p_0$; then, taking into account the relations

$$\frac{\partial \varepsilon_0}{\partial p_0}=-\frac{1}{g_0\rho_0}\frac{ds_0}{dr},\quad \frac{\partial \rho_0}{\partial p_0}=-\frac{1}{g_0\rho_0}\frac{d\rho_0}{dr}$$

in virtue of the equation of radiative equilibrium $\frac{dp_R}{dr} = -\frac{k\rho_0 H}{c}$, where k is the coefficient of opacity; H, the flux of radiation; c, velocity of light,—we obtain for any star $\mu = 1$, $\gamma = \beta + \frac{[4-3\beta]^2(\Gamma-1)}{\beta+12(1-\beta)(\Gamma-1)}$.

However may β vary inside the star, γ will always be no less than 4/3, and, probably, no more than 5/3. From the variational theory of characteristic numbers we may infer that the characteristic numbers λ_m, which we obtain after having replaced γ in equation (1) by its minimum value for the whole star, γ_m, will not exceed the corresponding numbers of λ considered by us. Considering the problem with $\gamma = \gamma_m$ and introducing instead of ξ the non-dimensional $\frac{\xi}{r} \equiv \xi_1$, we obtain, in place of (1), the pulsation equation ($\mu = 1$): $\frac{d^2\xi_1}{dr^2} + \left(\frac{4}{r} - \frac{g_0\rho_0}{p_0}\right)\frac{d\xi_1}{dr} + \frac{4-3\gamma_m}{\gamma_m}\frac{g_0\rho_0}{rp_0}\xi_1 = -\frac{\rho_0}{\gamma_m p_0}\lambda_m\xi_1$ -

By a method analogous to that applied by us when studying this equation for Emden's spheres (2), it can easily be shown that the least $\lambda_m \geqslant 0$ with $\gamma_m \geqslant \frac{4}{3}$. Consequently, any gaseous star is stable with respect to radial perturbations, irrespective of the changes in the relation between gas pressure and radiation, except the case when $\gamma = \frac{4}{3}$ throughout the star, i. e. the very case represented by a star in neutral equilibrium.

Now let us consider the white dwarfs. In the case of non-relativistic degeneracy of gas

$$\varepsilon_0 = \frac{3}{2}K\rho_0^{5/3} + aT_0^4 = \frac{3}{2}p_G + 3p_R; \quad Kp_0 = \rho_0^{5/3} + \frac{1}{3}aT_0^4 \equiv p_G + p_R$$

and an analogous computation gives $\gamma = \frac{4}{3} + \frac{1}{3}\beta$, $\mu = 1$.

For a degenerate matter $\frac{p_G}{p_R} \ll 1$, i. e. practically $\beta = 1$. Therefore $\gamma = \frac{5}{3}$ - the problem of the study of stability thus coinciding with the problem of stability of a polytrope Emden's sphere $n = \frac{3}{2}$ (2). Consequently, any white dwarf whose substance is in a non-relativistic degenerate state, is stable. In the case of relativistic degeneracy of gas $\varepsilon_0 = 3p_0$, $p_0 = K\rho_0^{4/3} + \frac{1}{3}aT_0^4$, and, irrespective of β, the value $\gamma = \frac{4}{3}$, while $\mu = 1$. Therefore the problem of stability coincides with that of a polytrope sphere $n = 3$. Consequently, a white dwarf, whose matter is in a state of relativistic degeneracy, is in neutral equilibrium.

The two last conclusions as to the stability of degenerate stars gofully to confirm some qualitative suggestions that have once been made by Landau (3).

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REFERENCES

1 S. Rosseland, Univ. Oslo Publ., No. 1 (1931). 2 A. B. Severny, C. R. Acad. Sci. URSS, XXX, No. 5 (1941). 3 L. Landau, Phys. ZS. d. Sowjetunion 1, 285 (1932).

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PHYSICS

ON THE INFLUENCE OF THIN DIELECTRIC FILMS ON THE MAGNETO-OPTICAL KERR-EFFECT IN THE FERROMAGNETIC MIRRORS

By M. M. NOSKOV

(Communicated by S. I. Wawilow, Member of the Academy, 29.I.1941)

The magnetization of a ferromagnetic body is accompanied with the special optical effect which is characteristic for the ferromagnetics, namely with the rotation of the polarization plane of light being reflected by the magnetized mirror. This rotation (the so-called magneto-optical Kerr-effect) is proportional to the magnitude of the magnetization J for every substance studied ([1]), reaching saturation in a magnetic field along with J, and disappearing with it near the Curie-point ([2]).

Du Bois ([3]) suggested to prepare the specimens under investigation in a form of a plate, light and magnetic field being directed along the perpendicular to the plate. Then, if the magnetization is not very close to saturation, $J=H/4\pi$ or $\alpha=KJ=H\,K/4\pi$, where K is the Kerr-constant and α is the rotation angle measured.

The maximum values of α do not surpass half a degree for all the substances that have been studied up to the present (more than 50 in number). K, the constant, cannot be calculated beforehand for any substance neither according to its magnitude, nor to its sign, the values of the magnetization alone being available. Thus, K has the qualities of independent «material constant».

It has been found that the thin films of the dielectric influence the rotation angle α in quite a peculiar way. If we cover the surface of the ferromagnetic mirror with a very thin film of a solution of nitrocellulose in acetone (instantly drying up), or with a film of very diluted bakelite varnish, or with a thin liquid film of some oil, then the Kerr-effect sharply increases.

Some of the experimental results obtained on the mirrors made of nickel, permalloy and iron (transformer steel) are described below. The specimens in a form of plates were placed between the poles of the electromagnet, in fields up to 20000 Öe. The light from a three phase alternating current arc lamp was monochromatized by letting it through a glass filter with the region of maximum transparency near $\lambda=0.58\,\mu$. The half-shaded device made it possible to determine the position of the polarization plane, the errors being no more than ± 0.02 degree. By changing the current direction in the electromagnet, the double effect has been observed.

For measuring the thickness the film was partly removed. Then by means of evaporation in vacuum the specimen was covered with a layer of gold, the thickness of which was no more than 0.1 μ. The depth of the mirror step obtained was measured with the help of Linnik's micro-interferometer ([4]),

by observing the displacement of the interference fringes. The films were found to be rather similar in thickness within the illuminated area of the specimens.

1) The solid cellulose or bakelite films, as well as liquid oil films (for instance, paraffin oil) some tenths of micron thick, being placed on the surface of nickel, permalloy or iron specimen, increased the magnetic rotation effect twice or one and a half times. This effect depended on the thickness of the films and re-assumed its initial value after the film had been removed.

2) The table below gives the double values of the magnetic rotation for one of the single-crystal specimens of transformer steel with cellulose films of different thickness. It shows the most advantageous thickness of film which increases the magnetic rotation about 2.4 times. The stimulating action of the film falls abruptly on both sides of this maximum.

Thickness of films (microns)	Rotation *	
	2 α (degrees)	α/α_0
0.00	0.56	1.00
0.05	0.77	1.38
0.07	1.34	2.38
0.10	1.145	2.04
0.12	0.91	1.63
0.15	0.845	1.50
0.35	0.80	1.45
0.39	0.70	1.25

* Force of the magnetic field $H = 17200$ Oe.

3) The field dependence of the increased effect followed the change of the normal effect in a magnetic field, reaching the saturation at the same values of the field.

4) An additional rotation of the polarization plane obtained in the presence of the film cannot be attributed to the Faraday effect in the film. None of the well known transparent dielectrics gives (with the fields used) rotation of about 28000°/cm, which should be attributed to the film showing the maximum effect. However, for the sake of control, the mirror made of chromium was also covered with a film. Then the magnetic rotation was not observed within the sensitivity of the device.

5) The multiple internal reflexions of light in the transparent film could serve as a possible source for the additional rotation. In such a case every next reflexion of light from the metal gives the polarization plane an additional shift through the angle α. However, owing to the small reflecting power of the transparent film, the intensity of the beams will decrease with the number of reflexions.

6) Let us take the conditions which are the most advantageous for the intensity of the beams directed to the observer: a) there is no absorption of light in the film, as well as no loss of light on reflexions from metal place, and b) the film is of such a thickness that the phase difference does not take place for any pair of beams leaving the film. Then the calculations bring us to the following formula for α_1, the angle of the polarization plane, increased owing to an infinite number of reflexions: $\operatorname{tg} \alpha_1 = \frac{\alpha_0 (1+\gamma)}{(1-\gamma)(1+2\gamma)}$ where α_0 is the rotation in the absence of a film, and $\gamma^2 = R = \left(\frac{n-1}{n+1}\right)^2$—the reflecting power of the boundary «film-air» in the case of normal incidence. The values of the refractive index n of the film being permissible, in spite of the assumptions (a) and (b) most favourable for the magnitude of α, the above formula is not able to satisfy the large values of α given in the table.

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REFERENCES

[1] Du Bois, Wied. Ann., **39**, 25 (1890). [2] Klitzing, ZS. Phys., **85**, 240 (1933). [3] Du Bois, Phil. Mag. (5), **29**, 239 (1890). [4] V. P. Linnik, Bull. Acad. Sci., URSS, sér. phys., No. 4—5, 505 (1937).

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PHYSICS

ABSORPTION OF ULTRASONIC WAVES IN VISCOUS LIQUIDS

By P. A. BAŽULIN

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Numerous experimental data concerning the absorption of ultrasonic waves in common not too viscous liquids demonstrate that the quadratic dependence of absorption on frequency is valid for the majority of liquids with a sufficiently wide frequency range (1). Nevertheless a serious discrepancy has been observed between experimental results and values calculated in accordance with Stokes' formula, when only the usual viscosity coefficient η has been taken into consideration.

In order to explain these results it must be assumed that a significant rôle in the general hydrodynamical formula for the absorption coefficient α is played by the second viscosity coefficient η', which accounts for heat dissipation in the case of uniform compression. Moreover, confining ourselves to the formal hydrodynamical theory, we are liable to encounter serious difficulties in attempting to explain a number of facts. Thus, for example, *the fine structure of the lines of Rayleigh light scattering in liquids*, the effect of insignificant admixtures on the absorption coefficient α and, finally, the fact that for a number of liquids the proportionality of the absorption coefficient to the square of the frequency does not hold true—are all inexplicable in terms of that theory.

L. Mandelstam and M. Leontovich (2) have shown, on the other hand, that the fine structure of the Rayleigh radiation can be explained, if the voluminal viscosity η' is looked upon as a relaxation phenomenon. In the simplest case a formula for the absorption coefficient may be derived on the basis of their theory, analogous to Kneser's formula for polyatomic gases. The theory in this form excludes the case of propagation of ultrasonic waves in mediums with high viscosity, i. e. the case when the usual viscosity coefficient η becomes an important factor. Here, in our particular case, difficulties are encountered in attempting to explain the fine structure of the Rayleigh radiation.

The condition essential for the appearance of a sufficiently clear structure of the lines is: $\alpha\Lambda \ll 1$, where Λ is the sound wave-length. If an attempt is made to extend Stokes' formula for viscous liquids to frequencies of 10^{10} Hz, which correspond to waves playing an important rôle in the molecular scattering of light, the expression $\alpha\Lambda \gg 1$ will be obtained. Thus, for example, for glycerine $\alpha\Lambda \cong 10$, i. e. no fine structure should practically be observed. As a matter of fact, it has been observed for some viscous liquids, among others for glycerine (3).

This discrepancy may be explained on the assumption that in general the phenomenon of viscosity is a relaxation phenomenon, fitting within the Maxwellian scheme. At the suggestion of L. Mandelstam, M. Issakovich ([4]) subjected to an examination the problem of the propagation of compressional waves in a liquid possessing not only voluminal relaxation, but shift relaxation, as well.

On this examination one comes in the simplest case to the following formulae for the velocity and the absorption coefficient, neglecting voluminal relaxation:

$$c_\omega - c = \frac{2}{3}\frac{\eta}{\rho c}\frac{\omega^2\tau}{1+\omega^2\tau^2} \tag{1}$$

$$\alpha = \frac{2}{3}\frac{\eta}{\rho c^3}\frac{\omega^2}{1+\omega^2\tau^2} \tag{2}$$

where c is Laplace's velocity at low frequencies, η is the usual viscosity coefficient, ω is the cyclic frequency, ρ is the density and τ—the relaxation time.

In connexion with these results it is of interest to obtain data, relating to the absorption and dispersion of ultrasonic waves in liquids of high viscosity. Some facts concerning dispersion in castor oil have already been obtained by L. Zachoval ([5]). The object of the present investigation, suggested by L. Mandelstam, is to obtain data on the absorption of ultrasonic waves.

In this paper are published some preliminary results of measuring the absorption of ultrasonic waves in glycerine within the frequency range of 6000—20000 kHz, and in castor oil within the frequency range of 4000—16000 kHz. The experimental method chosen for the investigation of absorption was that of Toepler ([6]). This method is highly convenient, for it permits comparatively great damping of the ultrasonic waves to be measured. The apparatus is arranged according to practically the same scheme as that employed in the diffraction method ([7]).

In our investigations the following precautions were taken. First of all, ultrasonic waves of low intensity only were used throughout the experiment. Diffraction phenomena observed in the focal plane of the second objective served to regulate this intensity, which was adjusted so as to give spectra of the first order only. Furthermore, to avoid heating of the liquid near the quartz, which would lead to a distortion of the picture by heat currents, there was provided a simultaneous switching in of the generator and camera for an extremely short period of time. And each time this was followed by a switch-off interval which lasted till the disappearance of the minutest heat currents; this was checked by the same optical method. Special experiments were also conducted to evaluate the effect of heating near the quartz. For this purpose a number of photographs were taken for a certain frequency, in which the periods of time, during which the generator was in operation, and also the time interval between two such successive operations, were varied. These measurements showed that the absorption coefficient, within the limits of experimental error, remained constant. This indicates that local heating was unable to affect the results significantly. That its influence was insignificant indeed, was proved by a study of the intensity drop of the ultrasonic wave amplitude along the acoustic field. This drop was found to be exponential.

Table 1 gives the results of measurements for glycerine, containing 50% water. The viscosity of glycerine $\eta = 4.1$ poises. Table 2 gives the results of similar measurements for castor oil. The viscosity of castor oil $\eta = 10.3$ poises. For each frequency in the tables the mean values of 10—15 observations are given. Error in measurement does not exceed 10%; α denotes the absorption coefficient for an amplitude of cm^{-1}; α'—the value of the absorption coef-

ficient calculated according to Stokes' formula. The ultrasonic velocity in castor oil was determined by the method of diffraction with respect to CCl_4. The viscosity was determined from the velocity of a pellet let to fall in the liquid.

Table 1

ν in kHz	$t°$ C	α exp.	$\frac{\alpha}{\nu^2} \times 10^{17}$ exper.	$\frac{\alpha'}{\nu^2} \times 10^{17}$ calc. at $t = 21°$ C
20660	21 —22	6.6	1600	1300
18960	21.1—21.2	6.4	1800	1300
14000	22.2—22.5	3.3	1700	1300
12430	22	2.8	1800	1300
9170	21.5—22	1.3	1600	1300
7560	20.8—21.7	1.0	1800	1300
5920	21.1—21.2	0.58	1700	1300

Table 2

ν in kHz	$t°$ C	α exp.	$\frac{\alpha}{\nu^2} \times 10^{17}$ exper.	$\frac{\alpha'}{\nu^2} \times 10^{17}$ calc. at $t = 21°$ C
15720	21.3—21.5	5.1	2100	8200
9230	20.4—21.1	2.7	3200	8200
7590	21.0—21.8	2.0	3500	8200
5940	20.8—21.8	1.5	4200	8200
4290	21.5—21.6	0.82	4500	8200

Comparing the results obtained experimentally with those calculated theoretically for glycerine, and taking into consideration only the usual viscosity coefficient η, it will be seen that the absorption in this frequency range comes close to follow Stokes' formula. The somewhat increased values are possibly due to the non-homogeneity of the medium, viz. our mixture ([8]). A comparison of experimental and calculated values for castor oil, on the other hand, displays a sharp deviation from Stokes' formula.

From Table 2 it follows, first of all, that absorption does not obey the square law when it varies with frequency. Moreover the absolute value of α is considerably less than that calculated according to Stoke's formula. Thus, for example, for the frequency 15000 kHz it is approximately 4 times as small. It must be noted, however, that with the decrease in frequency, the difference between experimental values and those calculated in accordance with Stokes' formula becomes less. A similar lessening of difference, as preliminary experiments have shown, takes place if measurements are made at a raised temperature.

From the standpoint of the relaxation theory of viscosity, spoken of above, our experimental results could be interpreted in the following manner. In glycerine we are still in that frequency range, where the effect of shift relaxation does not make itself felt; absorption obeys the usual Stokes' formula. For castor oil we must assume, from this point of view, that we are already in that frequency range where the relaxation effect begins to play a significant part, therefore absorption begins to increase with frequency more slowly than does ω^2.

It is evident from formula (2) that for castor oil the quadratic relation between α and ω ceases to hold at values of $\omega \cong 6000$ kHz, and, consequently, at these values the expression $\omega^2\tau^2$ must be considerably greater than unity. From this the order of the relaxation time may be evaluated as $\tau \approx 10^{-8}$ sec. Of course, this time period can only be looked upon as approximate, for the Maxwellian scheme itself cannot claim to give an exact quantitative interpretation of the phenomenon, although it seems to bring out its true character qualitatively.

It is of interest to note that employing Zachoval's ([5]) dispersion data and formula (1), a value of the same order for τ will be obtained.

In conclusion it must be mentioned that castor oil is not as good an object for theoretical interpretation as other individual chemical substances. However, the author is of the opinion that it is possible to carry out a first series of experiments with it, for castor oil has an invariable and trustworthy viscosity coefficient, and, finally, data are available, as it was already mentioned, concerning dispersion in it ([5]).

At the present time we are continuing a systematic study of the absorption of ultrasonic waves, depending on frequency and temperature, in various viscous liquids.

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REFERENCES

[1] P. Biquard, Thèse, Paris (1935); P. Bažulin, Sow. Phys., **8**, 354 (1935); П. Бажулин, ЖЭТФ, **8**, 457 (1938); J. Claeys, J. Errera and H. Sack, Trans. Farad. Soc., **33**, 136 (1937); R. Bär, Helv. Phys. Acta, **10**, 333 (1937); H. Grobe, Phys. ZS., **39**, 333 (1938); W. Buss, Ann. d. Phys., **33**, 143 (1938). [2] L. I. Mandelstam and M. A. Leontovich, C. R. Acad. Sci. URSS, III, No. 3 (1936); Л. А. Мандельштам и М. А. Леонтович, ЖЭТФ, **7**, 438 (1937). [3] C. V. Raman, C. S. Venkateswaran, Nature, **142**, 791 (1938). [4] M. A. Issakovich, C. R. Acad. Sci. URSS, XXIII, 782 (1939). [5] L. Zachoval, C. R., **208**, 265 (1939). [6] F. A. Korolev, C. R. Acad. Sci. URSS, XV, 35 (1937). [7] П. Бажулин, ЖЭТФ, **8**, 457 (1938). [8] P. A. Bažulin and J. M. Merson, C. R. Acad. Sci. URSS, XXIV, 689 (1939).

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GEOPHYSICS

SYMMETRY OF THE MAGNETIC FIELD IN POLAR REGIONS

By B. P. WEINBERG

(Communicated by P. P. Lasareff, Member of the Academy, 20.I.1941)

The examination of charts of magnetic meridians in the Arctic and Antarctic shows a marked symmetry in the distribution of meridians. This

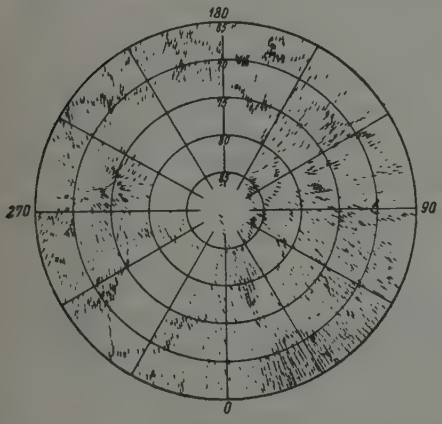

Fig. 1.

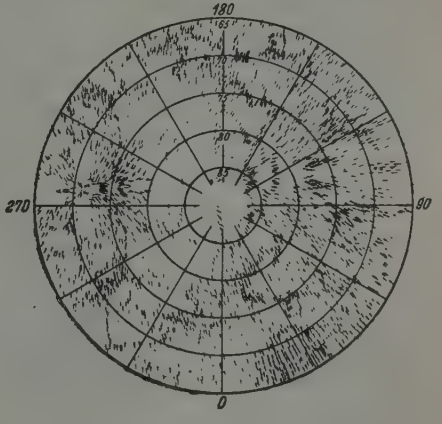

Fig. 2.

may be seen in Fig. 1, in which arrows denote the results of determinations of declination reduced to 1940 (1) (thicker arrows correspond to the averaged results of determinations in two or more neighbouring points). The big circle passing through the point $\varphi = 71°$, $\lambda = 265°$—«the quasi-stationary north magnetic pole», according to K. Weinberg's terminology (2), and through the point $\varphi = 86.5°$, $\lambda = 165°$—«the rotating north magnetic pole», as approximately determined from V. Bujnitsky's observations on the ice-breaker «Sedov»—may be taken as a plane of symmetry in the Arctic.

The symmetry is still more pronounced in Fig. 2 which represents the chart of Fig. 1, in which, besides its arrows, are plotted by straight lines (without arrow-heads) of the same length the mirror images of the same arrows in this symmetry plane.

A similar symmetry may be observed on other magnetic charts of the Arctic representing the presumed distribution of such magnetic elements

which are not associated with the geographic net. This is shown in the table in which are recorded the latitudes of intersections of several meridians with similar lines of symmetry on the charts of Haussmann ([3]), Fisk ([4]) and also on the charts that have been previously prepared by the author of the present paper for the Polar Catalogue ([1]).

Latitudes of Intersections of Lines of Symmetry with Several Meridians on Various Charts

Author of the chart	Recorded element	$\lambda = 120$	150	180	210	230	250
Haussman	Magnetic meridians	82.9	85.5	87.0	86.5	85.0	82.5
Fisk	» »	82.0	85.0	85.5	85.0	84.0	79.5
»	Inclination	80.0	84.0	85.0	84.5	83.0	80.0
»	Horizontal component . .	81.0	85.0	85.5	85.0	84.5	80.0
B. Weinberg	Inclination	82.0	85.0	86.0	85.5	84.0	80.0
» »	Horizontal component . .	81.0	85.0	86.0	85.5	84.0	80.0
» »	Fig. 1	82.0	85.5	86.5	86.0	85.0	81.5

Owing to the marked proximity of directions of arrows and lines in Fig. 2 nearly in all districts, where they both are present, use may be made, on the one hand, of similar mirror images of all magnetic isolines (except isogones and isodynes X and Y) in order to draw them with greater certitude (although in broken lines) also in those districts of polar regions where no direct determinations (or calculations from direct determinations) of corresponding magnetic elements have been carried out. On the other hand, a comparison of two such systems of isolines may serve as an indication of the presence and location of regional anomalies and also will aid in establishing the boundaries to which such a symmetry of the magnetic field extends on both sides of the indicated symmetry plane.

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4.I.1941.

REFERENCES

[1] Б. П. Вейнберг, Каталог магнитных определений в полярных областях (1941). [2] К. Б. Вейнберг, Изв. ОМЕН АН, 239 (1937). [3] K. Haussmann, Genäherte magnetische Meridianen für 1930 (1929). [4] W. Harlan, Fisk, Trans. Amer. Geophys. Union, **12**, 134 (1931).

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BIOPHYSICS

DISCRETENESS OF SENSATION

By S. LIFSHITZ

(Communicated by L. A. Orbeli, Member of the Academy, 28.I.1941)

In the present investigation the author develops the work discussed by him in previous papers ([1], [2]). As will be seen from the experiments described below, investigation proved that both integral laws of hearing perception and the fluctuation of the hearing threshold, discovered by the author, become a single case of a general phenomenon—the discreteness of sensations.

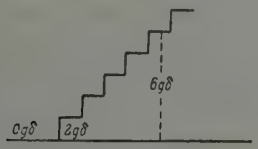

Fig. 1.

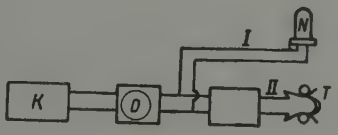

Fig. 2.

The integral law of loudness is $L=\lg\int Idt=\lg(It)$, where I is intensity of sound ant t—time. The intensities of sound being the same, loudness L increases with the time of its duration.

The integral law of duration is: $D=\int \lg I\times dt=\lg I\times t$. The apparent duration of the impulse D depends on its loudness.

«The fluctuation of the hearing threshold» consists in the following: the hearing threshold becomes unstable when the level of loudness is 6 db., and makes fluctuations with an amplitude of 2 decibels.

Both integral laws and the fluctuation of hearing threshold, as seen from direct experiments, can be applied to the functioning of other sense organs—vision and touch. In this case, I represents the force of the stimulus in general*, while the fluctuation of the hearing threshold is extended so as to include the fluctuation of the threshold of the senses.

Discreteness of sensations makes it possible to explain the fluctuation of the sense threshold in the following way. With an uninterrupted stimulus, the sensation rises stepwise. The magnitude of the step is equivalent to 2 db.**, i. e. the intensity of the stimulus increases by 0.6 of the threshold magnitude. We observed five such steps until the level of 6 db. (Fig. 1). Later the steps

* In the case of vision—the intensity of the light or the light stream; in the case of hearing—the intensity of sound or sound stream; in the case of touch—electrical power.

** The number of decibe s $N=10\lg I/i$, where I is the threshold value of the stimulus. When $I=i$, $N=0$ db.; when $I=1.6\,i$, $N=2$ db.; when $I=4\,i$, $N=6$ db. etc.

become unnoticeable as compared with the increased magnitude of sensation. 2 db. becomes the constant for the investigated sensations. We call it the elementary quantity of sensation.

The integral law of loudness, lg (It), signifies that when there is an uninterrupted stimulus I, a certain amount of time is necessary in order to perceive the element of sensation.

The integral law of duration for high levels is explained by psychological factors; for low levels the apparent shortening of the impulse is explained by its physiological shortening, since at the beginning of the impulse there are no sensations, the necessary elementary quantity of the impulse having had no time to accumulate.

Fig. 2 shows the apparatus with which the experiments were conducted. A cathode generator K feeds a neon tube for visual perception, a telephone or reproducer—for sound perception, and an enamel ring with two points, which is worn on the tongue,—for tactual perception. A rotating disc with a contact furnishes the impulse of a given duration.

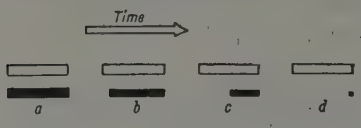

Fig. 3.

In the experiments described below the duration of the impulses was 0.75 sec., with similar intervals between them.

The disc D rotated with the help of synchronous motor, one and the same contact was switched on and off, thus securing a complete repetition of the impulses. Beyond the rotating disc D the circuit is furcated. One circuit, I, feeds an unchanging impulse which serves as an indicator; the other circuit, II, with the help of an attenuator A which is divided into decibels, feeds an impulse whose brightness or loudness changes.

In Fig. 2 the control is a light impulse (N—neon tube) for example. The impulse which is being investigated and which is subject to change is the sound impulse (T—telephone). Such is the arrangement of the reproducing instruments with which the investigation of sound sensation is conducted.

When visual sensation was being studied, the respective positions of the neon tube and the telephone were changed. The lamp was included in circuit II and the telephone in circuit I, and it served as indicator. When the sensation of touch in circuit II was studied, the enamel ring with the two points was inserted on the tip of the tongue in such a way that both points touch the tongue. The sensation of touch was produced by an alternating current of sound frequency from the generator. When studying the visual, sound and tactual impulses with the apparatus described above, we found that all impulses change in exactly the same way when the intensity of the stimulus is reduced.

Fig. 3 shows the change in the impulse being studied as compared with the control. The upper light impulse is the control impulse and remains unchanged throughout the experiments. The lower impulse is the one being studied. In the beginning, when the intensity of the stimulus is sufficient, the perception of both impulses is exactly alike as regards the time element: both begin and end simultaneously (Fig. 3, a). Later, as the intensity of the stimulus decreases, the impulse under investigation begins to lag slightly behind; however, it ends at the same time as the control (Fig. 3, b). Still later, the impulse under investigation lags more and more, by $^1/_3$ and $^1/_2$ of the control (Fig. 3, c). Finally, when we reach the limit, at a level of 2 db., the investigated impulse becomes a single dot, a single element of sensation (Fig. 3, d).

By using the integral law of loudness we can calculate the degree of lagging corresponding to the given levels. If t_1 is the length of the impulse, and Δt_1 is the degree of lagging in the case of a stimulus intensity I_2, we have

$$10 \lg I_2/i_1 = \left(2 + 10 \lg \frac{t_1}{\Delta t_1}\right) \text{ decibels.} \quad (1)$$

On the basis of equation (1) we should expect a scarcely noticeable lagging (considering $^1/_{20}$ sec. as scarcely noticeable, as is known from the experiments with echoes) at a level of 14 db.*, a lagging by $^1/_3$ of the impulse at a level of 7 db., by $^1/_2$ of the impulse at a level of 5 db., and a sensitivity threshold at a level of 0 db.

By the sensitivity threshold of a given observer we understand such an intensity of stimulus with which all sensations vanish. This threshold is determined with the aid of the same apparatus.

The results of the experiments are given in Tables 1, 2 and 3.

Table 1

Sound Impulse Investigated. As Control Impulse Serves the Light Impulse (Frequency 1000 Hz)

	Observers										
	S. Y.	V. L.	B. A.	Y. M.	N. A.	I. L.	S. S.	M. N.	Sr. S.	A. M.	Mean
Lagging scarcely noticeable	13	13	16	11	16	9	18	12	11	14	14 db.
Lagging by $^1/_3$ of the impulse	7	8	7	7	8	7	8	7	6	7.5	7 »
Lagging by $^1/_2$ of the impulse	5	4	4	4	5	4	7	4	4	5.5	4.7»
Hearing threshold	0	0	0	0	0	0	0	0	0	0	0 »

Table 2

Light Impulse Investigated. As Control Impulse Serves the Sound Impulse (Frequency 1000 Hz)

	Observers								
	S. Y.	M. N.	Y. A.	N. A.	B. E.	S. G.	L. A.	V. D.	Mean
Lagging scarcely noticeable	14.2	17.3	16.7	14	16	12	13	14	15 db.
Lagging by $^1/_3$ of the impulse	7.6	7.6	7.5	6.3	7.2	6.2	10	9	7.4 »
Lagging by $^1/_2$ of the impulse	4.3	5.5	5	4.7	3.4	3.2	5	3	4.6 »
Visual threshold	0	0	0	0	0	0	0	0	0 »

As seen from the tables, the visual, auditory and tactual impulses are perceived in the same way both qualitatively and quantitatively (in decibels), i. e., provided the absolute value for the threshold of feeling is exclu-

* 14, 7 and 5 decibels correspond to the intensity of stimulus of 25, 5 and 3 times above the threshold value.

Table 3

Tactual Impulse Investigated. As Control Impulse Serves either Light or Sound (Frequency 1000 Hz)

	Observers						
	R.Y.	A.N.	Sr.S.	M.N.	S.S.	S.Y.	Mean
Lagging scarcely noticeable	10	11	17	19	11	11	13 db.
Lagging by $^1/_3$ of the impulse . . .	7	6	12	10	8	7	8 »
Lagging by $^1/_2$ of the impulse . . .	4	3	8	6	4.5	5	5 »
Threshold of touch	0	0	0	0	0	0	0 »

ded. The elementar quantity of feeling, equal to 2 db., is also the same for all cases.

In connexion with the fact that a certain amount of time is necessary to perceive the element of sensation, when the stimulus is weak, we discovered a new visual phenomenon which we called the «elementary visual run». This phenomenon consists in the following. A narrow opening is cut in the case enclosing the neon tube. It is illuminated evenly by the lamp. An optical wedge is put on this opening, and through it one end of the slit appears bright, gradually fading off towards the other dark end. At the moment when the tube is lit, the light gradually spreads from the bright to the dark end.

The time of this spreading, t_2, is determined from the equation:

$$10 \lg I_1/i_1 - 10 \lg I_2/i_2 = (13 + 10 \lg t_2) \text{ decibels} \qquad (2)$$

I_1 and I_2 being the intensity of the light at the bright and dark ends.

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30.I.1941.

REFERENCES

[1] Lifshitz, Phys. Rev., **25** (1925); **27** (1926); Journ. of the Acous. Soc. Amer., IV (1932); **5** (1933); **7** (1936); **11** (1938). [2] Lifshitz, C. R. Acad. Sci. URSS, II, No. 3 (1934); XV, No. 6—7 (1937); No. 5 (1938).

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CHEMISTRY

ON THE PROTOZOIC ACTIVITY OF SOME PHENOLS

By N. N. MELNIKOV, A. M. AVETESIAN and M. S. ROKITSKAYA

(Communicated by S. S. Nametkin, Member of the Academy, 17.I.1941)

During the last years different phenol derivatives have been attracting the attention of investigators by their high bactericidal and helminthagogic action. Many phenol derivatives are widely used as antiseptic (1), desinfecting (2) and therapeutical agents (3). Nevertheless, the mechanism of the action of phenol on various microorganisms is far from being evident. It would be a long step towards a successful solution of this problem, if one succeeded with different microorganisms to establish the nature and character of their pellicle, as well as the sorption of desinfecting agents by it and by the body. The study of the protozoic activity of phenols would also widen the list of substances that could be used in the struggle against these species of microorganisms.

In the present paper an attempt has been made to follow the connexion between the chemical constitution and the efficacy of various phenol derivatives against protozoa. The tests were carried out with *Paramaecium caudatum* which is the most easily available object.

As most phenols are either insoluble or poorly soluble in water, well soluble sodium phenolates were prepared and their action was studied. 24 compounds were investigated in all. As a standard for comparison sodium phenolate was used. Lethal doses of a substance were considered those which caused a complete destruction of *Paramaecium caudatum* in 30 minutes.

The following regularities were deduced from the experiments:

1. Increasing the chlorine content in the molecule of phenol goes far to render this compound more efficacious against *Paramaecium caudatum*. A particularly brusque increase in activity takes place when passing from phenol to penta- and tetrachlorophenols. The less active compound among those investigated proved to be trichlorophenol and the most active one—tetrachlorophenol. This can be seen particularly well from a comparison of molecular phenol coefficients. The data are given in Table 1.

2. Different substituting groups in the para-position to the hydroxyl group increase the activity of the phenol, the only exception being positive groups, such as nitro-, sulpho- etc., which tend to make it somewhat less active. A more efficacious compound is also obtained, as a rule, by the substitution of hydrogen through a hydrocarbon radical. Results obtained in testing compounds of this kind are given in Table 2.

3. The activity of alkylphenols increases with an increase of the molecular weight of the radical which substitutes hydrogen. This increase in effi-

Table 1

Formula	Phenol coefficient	Molecular phenol coefficient
C_6H_5ONa	1	1
p-ClC_6H_4ONa . .	2.6	3.4
$2.4Cl_2C_6H_3ONa$.	1.6	2.7
$2.4.6Cl_3C_6H_2ONa$.	1	2.1
Cl_4C_6HONa . . .	11.6	26.2
C_6Cl_5ONa	8.7	22.7

Table 2

Formula	Phenol coefficient	Molecular phenol coefficient
C_6H_5ONa	1	1
p-ClC_6H_4ONa . .	2.6	3.4
p-$C_6H_5C_6H_4ONa$.	7.7	13.1
p-$CNSC_6H_4ONa$.	44	66.4
p-$NO_2C_6H_4ONa$.	0.2	0.3
p-$C_2H_5C_6H_4ONa$.	2	2.5
p-$C_6H_5CH_2C_6H_4ONa$	36	66.2

cacy is particularly considerable when hydrogen is substituted with benzyl. The data on alkylphenols are given in Table 3.

Table 3

Formula	Phenol coefficient	Molecular phenol coefficient
C_6H_5ONa	1	1
$CH_3C_6H_4ONa$ . . .	0.7	0.8
$C_2H_5C_6H_4ONa$ . .	2	2.5
$C_3H_7C_6H_4ONa$ . .	4.2	5.6
$C_4H_9C_6H_4ONa$ . .	52.6	78.9
p-$C_6H_5C_6H_4ONa$.	7.7	13.1
o-$C_6H_5C_6H_4ONa$.	2.5	4.8
p-$C_6H_5CH_2C_6H_4ONa$	36	66.2
$(CH_3)(C_4H_9)C_6H_3ONa$.	36	59.4

Table 4

Formula	Phenol coefficient	Molecular phenol coefficient
$C_2H_5C_6H_3ClONa$.	9	14.9
$C_4H_9C_6H_3ClONa$.	205	404.6
$C_4H_9C_6H_2Cl_2ONa$.	90.3	210.3
$C_6H_5C_6H_3$ (ONa (2), Cl (3))	7.8	16.9
$C_6H_5C_6H_3$ (ONa (3), Cl (5))	43.5	95
$C_6H_5C_6H_3$ (ONa (2), (Cl_2) (3.5))	34.4	88.4

4. Alkylchlorophenols and arylchlorophenols are much more active than the corresponding compounds containing no halogen. Data are tabulated in Table 4.

The comparison of the experimental data given above with the corresponding data obtained on bacteria by different investigators shows that the toxicity of phenol derivatives in the case of different microorganisms changes collaterally. This indicates that the mechanism of the action of phenol derivatives upon *Paramaecium caudatum* and upon some other bacteria is similar. It is possible that certain bacteria and protozoa have pellicles similar in constitution and composition.

Received
17.I.1941.

REFERENCES

[1] Carlswell and Nason, Ind. Eng. Chem., **30**, 622 (1938); Fuller, ibid., **26**, 946 (1934). [2] Rapps, J. Soc. Chem. Ind., **52**, 175 (1933); Amer. Pat. 2002447, 2010505; German Pat. 495717, 579897, 667063. [3] Klarmann, Gates and Shternow, J. Am. Chem. Soc., **53**, 3397 (1931); **54**, 1204, 298, 3315 (1932); **55**, 2582 1933).

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CHEMISTRY

DERIVATIVES OF 2-HYDROXYBIPHENYL

By N. N. MELNIKOV, M. S. ROKITSKAYA and Z. E. BECKER

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As is well known, among a large number of organic compounds proposed as antiseptic and bactericidal agents, the most potent germ-killing substances and fungicides, next to organometallic compounds of mercury, are different phenol derivatives (1). As an antiseptic, for the preservation of different articles from destruction by microorganisms, hydroxybiphenyl and its derivatives are widely used (2,3). Among the latter alkyl- and alkylhalogenhydroxybiphenyls should be mentioned (4, 5). However, the comparatively high cost depending to a considerable degree on complication connected with their synthesis, hinders the commercial production of hydroxybiphenyl derivatives on any large scale (6).

This was the reason for our searching of simpler methods for the synthesis of alkyl- and alkylchlorohydrobiphenyls. We came to the conclusion, as a result of our experiments, that alkylhydroxybiphenyls and alkylchlorobiphenyls could be prepared through the condensation of alcohols with hydroxybiphenyl in the presence of anhydrous aluminium chloride (similarly with the synthesis of alkylphenols) (7).

For the alkylation of hydroxybiphenyl or chlorohydroxybiphenyl, two moles of anhydrous aluminium chloride were added to a mixture of equimolecular amounts of hydroxybiphenyl and alcohol, and the reaction mixture was refluxed on an oil bath at 120—180° for a few hours. When the reaction came to an end, the dark product was decomposed with 5% HCl, the oily layer separated and distilled in vacuo.

In order to recover hydroxybiphenyl, the alkylhydroxybiphenyl was treated with a 5% aqueous solution of sodium hydroxide at 50—60°*. The oil insoluble in alkali was fractionated in vacuo. The yield of alkylhydroxybiphenyl was 40—70%, calculated for the hydroxybiphenyl that entered the reaction. Alkylhydroxybiphenyls and alkylchlorohydroxy-

Table 1

Name	d_4^{20}	n_D^{20}
Ethyl-2-hydroxybiphenyl	1.0944	1.6022
Ethyl-5-chloro-2-hydroxybiphenyl	1.1656	1.6146
Propyl-2-hydroxybiphenyl . . .	1.0505	1.5834
Propylchloro-2-hydroxybiphenyl	1.1420	1.5919
Butyl-2-hydroxybiphenyl	1.0312	1.5778
Butylchloro-2-hydroxybiphenyl .	1.1376	1.5882
Isoamylchloro-2-hydroxybiphenyl	1.1280	1.5894
Octyl-2-hydroxybiphenyl	1.0136	1.5641
Octylchloro-2-hydroxybiphenyl .	1.0883	1.5725
Diethyl-2-hydroxybiphenyl . . .	1.0498	1.5912
Dipropyl-2-hydroxybiphenyl . .	1.0768	1.5840

* In alkalies of such a concentration only hydroxybiphenyl is soluble; alkylhydroxybiphenyls are soluble only in sodium hydroxide solutions of a higher concentration.

Table 2

	Monilia sitophyla				*Alternaria humicola*		*Fusarium* sp.		*Ustilago panici miliacei*		*Chaetomium murorum*		*Penicillium expansum*	
	Fungicide efficacy		Antiseptic efficacy											
	ph. c.	m. ph. c.	ph. c.	m. ph. c.	ph. c.	m. ph. c.	ph. c.	m. ph. c.	ph. c.	m. ph. c.	ph. c.	m. ph. c.	ph. c.	m. ph. c.
2-hydroxybiphenyl	13	23	111	200	118	222	111	200	138	250	22	40	14	25
Ethyl-2-hydroxybiphenyl	6	12	123	250	9.5	20	212	444	8100	17000	760	1600	810	1700
Propyl-2-hydroxybiphenyl	3	7	178	400	22	50	44.5	100	75.5	170	50.5	114	370	833
Butyl-2-hydroxybiphenyl	3	7	138	333	8	20	28	67	71	170	7	16	1200	2500
Isoamyl-2-hydroxybiphenyl	3	7.7	112	286	260	660	31	80	98	250	11	27	2180	5500
Dipropyl-2-hydroxybiphenyl	260	700	740	2000	186	500	15	40	9300	25000	42	114	930	2500
Chloro-2-hydroxybiphenyl	161	350	460	1000	116	260	920	2000	116	250	18.4	40	116	250
Ethylchloro-2-hydroxybiphenyl	4730	11700	9000	22200	162	400	—	—	25400	62500	360	889	—	—
Propylchloro-2-hydroxybiphenyl	0.5	1.4	382	1000	382	1000	765	2000	480	1250	30.5	80	9.5	25
Butylchloro-2-hydroxybiphenyl	0.5	1.4	73	200	0.15	0.4	0.3	0.8	36	100	73	200	—	—
Isoamylchloro-2-hydroxybiphenyl	0.6	1.7	345	1000	0.07	0.2	0.3	0.8	172	500	30	88	43	125

Note: ph. c. — phenol coefficient, m. ph. c. — molecular phenol coefficient.

biphenyls obtained by this method as well as their properties are given in Table 1.

Alkylchlorohydroxybiphenyls were obtained both through the condensation of alcohols with chlorohydroxybiphenyl and through the chlorination of alkylhydroxybiphenyls with chlorine and sulphuryl chloride. It should be noted that the condensation of hydroxybiphenyl with alcohols yielded a mixture of isomeric alkylhydroxybiphenyls and that their separation was not effected by us, as this had no essential meaning for practical purposes. Next to alkylhydroxybiphenyls in this reaction a certain amount of dialkylhydroxybiphenyls and trialkylhydroxybiphenyls were obtained. As polyalkylhydroxybiphenyls have a higher boiling point, their separation from monoalkylhydroxybiphenyls presented no difficulties.

In order to find out the possible application of the compounds obtained in different branches of national economy, their antiseptic properties were tested upon fungus-parasites. *Monilia sitophyla*, *Alternaria humicola* and *Chaetomium murorum* were selected as representatives of microorganisms destroying wood. As representatives of fungi affecting fruits and vegetables *Fusarium* sp., *Alternaria humicola* and *Penicillium expansum* were used, as well as *Ustilago panici miliacei*, a smut fungus.

The coefficients characterizing the efficacy of the antiseptic compounds investigated against the microorganisms mentioned above are given in Table 2.

As may be seen from Table 2, the majority of the compounds investigated are effec-

tive antiseptic agents, their potency exceeding many times that of phenol and hydroxybiphenyl. It should be noted that the antiseptic effect of the investigated hydroxybiphenyl derivatives upon different microorganisms can vary within a very broad range.

When examining the influence of different substituting groups in the molecule of hydroxybiphenyl, a conclusion can be drawn, that this influence is the same as the one observed among phenol derivatives. Thus, for instance, the antiseptic efficacy increases with an increase of the molecular weight of the side-chain. But the rise in antiseptic activity with the increase of molecular weight of the compound takes place only to a certain degree, as in the case of phenol derivatives, after which the antiseptic potency decreases sharply. The same phenomenon was observed in the case of derivatives of chlorohydroxybiphenyl.

Alkylchloroxybiphenyls are more active than the corresponding alkylhydroxybiphenyls against certain microorganisms, but less active against other ones.

Some practical conclusions can be drawn on the base of the data obtained. As the animal organism is not seriously affected by alkylhydroxybiphenyls, they may be recommended for the preservation of citrus fruits from decay. It is well known that citrus fruits are attacked mainly by the fungus *Penicillium* resistant towards acids. Experiments should also be staged on treating cereal seeds for smut with these compounds.

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REFERENCES

[1] Klarmann, Gates and Shternow, J. Am. Ch. Soc., **53**, 3397 (1931); **54**, 1204, 298, 3315 (1932); **55**, 2582 (1933). [2] Fuller, Ind. Eng. Chem., **26**, 946 (1934). [3] M. Troitzky, Bull. Acad. Sci. URSS, No. 1, 127 (1940). [4] Amer. Pat. 2092724, 2092725, 2138471, 2135978. [5] Harries and Christiansen, J. Am. Pharm Ass., **23**, 580 (1934); **24**, 553 (1935). [6] Н. Мельников и Вольфсон, Пр. О. Х., № 11 (1939). [7] Цукерваник и Назарова, ЖОХ, 5, 764 (1935); 7, 623 (1937); 8, № 16 (1938).

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PHYSICAL CHEMISTRY

EXPLOSIVE OXIDATION OF SULPHUR MONOXIDE

By H. KONDRATJEWA and V. KONDRATJEW

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Sulphur monoxide, discovered by Schenk (1), is formed during the oxidation of sulphur and its compounds, as one of the main intermediate substances. Especially elaborate studies by Pavlov, Semenov and Emanuel (2) have shown that considerable quantities of sulphur monoxide form in the initial stage of oxidation of hydrogen sulphide; thus, sulphur monoxide is one of the first oxidation products of H_2S. The ignition of H_2S is probably due to sufficient accumulation of the monoxide.

It will therefore be obvious that sulphur monoxide plays an important part in the kinetics of the oxidation of sulphur and its compounds. So we undertook an experimental study of the oxidation of sulphur monoxide itself. Our experiments showed that this reaction was a typical chain reaction.

We produced sulphur monoxide after the method worked out by Schenk. The reaction vessel was a quartz tube 2 cm in diameter and 30 cm long, furnished with transparent windows. The velocity of the reaction was determined by the rate of disappearance of the monoxide absorption spectrum. In the first stage of the work, which is described here, the velocity was taken equal to the inverse time of complete disappearance of the monoxide bands from the absorption spectrum of the gas in the reaction vessel.

The experiments consisted in measuring the reaction velocities at various temperatures as a function of the pressure of oxygen, the partial pressure of the monoxide remaining constant and equal to about 0.5 mm Hg. Pressure was measured by means of a sulphuric acid manometer. The pressure and temperature intervals were, respectively, 3—13 mm Hg and 54—144° C. These experiments have shown that with each temperature in the mentioned interval the reaction velocity rises rapidly as the pressure of O_2, and therefore as the total pressure increases, and becomes immeasurable when the pressure reaches its critical value. The critical pressures p_1 measured by us satisfy the following equation: $p_1 = 0.5e^{\frac{2140}{RT}}$ mm Hg.

Visual observations show, that if oxygen is forced into a vessel containing the monoxide with $p > p_1$, there is a slight flash (blue in colour) which lasts a few seconds. Near p_1 an induction period, lasting about 2 min. at the lowest temperatures studied, is also observed. Thus, it is beyond doubt that the oxidation of sulphur monoxide is a chain reaction. The comparatively long flashes show that the chains have few branches. The critical pressure p_1 corresponds to the lower ignition limit of the monoxide.

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REFERENCES

(1) P. W. Schenk, ZS. anorg. allg. Chem., 211, 150 (1933). (2) D. Pavlov, N. Semenov and N. Emanuel, C. R. Acad. Sci. URSS, XXVIII, 618 (1940).

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BIOCHEMIE

ÜBER DIE KRISTALLISATION VON ALBUMINEN AUS MENSCHLICHEM MUSKEL

Von TADEUSZ BARANOWSKI

(Vorgelegt von A. N. Bach, Mitglied der Akademie, den 28.I.1941)

In der vorigen Mitteilung (1) wurde über die Darstellung von kristallisiertem Myogen aus menschlicher Muskulatur berichtet. Die Kristalle hatten die Form der Dodekaeder mit rhombischen Wänden und wurden provisorisch als Myogen-A-Kristalle bezeichnet. In der vorliegenden Mitteilung wird über die Darstellung weiterer kristalliner Proteine aus menschlichem Muskel berichtet.

Die mit Wasser extrahierbaren Proteine des menschlichen Muskelbreies erwiesen sich aus vielen Gründen besonders interessant. Erstens: die Kristallisation dieser Proteine gelingt verhältnissmässig leicht. Zweitens: man erhält eine grössere Anzahl kristallisierter Eiweisskörper. Die Eigenschaften dieser, in kristalliner Form dargestellten Proteine unterscheiden sich merklich von den Eigenschaften derjenigen, welche aus Kaninchenfleisch mit derselben Methode gewonnen wurden.

Die menschlichen Muskeln stammten aus dem sezierten Leichenmaterial, 24 Stunden nach dem Tode. Das erste Mal wurde insgesamt 400 g menschlicher Muskel verarbeitet, nach der gewöhnlich von mir verwendeten Methode. Das Endvolumen der Eiweisslösung betrug 6 cm^3, pH der Lösung lag in diesen wie auch in den folgenden Versuchen bei 5.6. Nach 24-stündlichem Stehen der mit Ammoniumsulfat bis zur schwachen Trübung versetzten Eiweisslösung im Eisschrank fielen grosse, dodekaederähnliche Kristalle aus. Die Kristalle sind deutlich doppelbrechend. Diese Kristalle zeigten die Eigenschaften der Proteine. Das Umkristallisieren führt zu Formen, die als verschiedene Modifikationen der Hauptform erscheinen, je nach den Kristallisationsbedingungen. Aus Proteinlösungen von verschiedener Konzentration bekommt man auch oktaederähnliche Kristalle, bei denen die Ecken manchmal abgestumpft sind (Abb. 1). In einem anderen Versuch wurden zwei identische Auszüge gleichzeitig verarbeitet. In der einen Portion erschienen die typischen Dodekaeder, in der zweiten erhielt ich kurze und dicke Stäbchen. Die weiteren Versuche zeigten, dass diese Stäbchen nur eine in der Hauptachse ausgezogene Modifikation der Hauptform sind und nach dem Umkristallisieren in die letztgenannte gehen. Dieses kristallisierte Muskelprotein aus Menschenmuskel nannte ich vorläufig Myogen A, ich möchte aber auf Grund der weiteren Beobachtungen betonen, dass die Eigenschaften dieses Proteins gegen die Annahme sprechen, dass es dem Myogen A des Kaninchenmuskels ähnlich wäre. Die Unterschiede treten scharf in der Lös-

lichkeit der beiden hervor. Das Myogen A aus Kaninchenfleisch löst sich ausgezeichnet in Wasser, man erhält leicht bis 20% Lösung davon. Die Kristalle des menschlichen Myogens A lösen sich viel schwerer; die Löslichkeit ist noch nicht genau bestimmt, sie überschreitet aber sicher einige Prozente nicht. Die Lösung ist deutlich viskos.

Weitere kristallisierte menschliche Muskelalbumine erhält man, wenn man die Mutterlaugen nach Abtrennen des Myogens A mit Ammoniumsulfat weiter versetzt. Aus solchen Lösungen fallen nach Ablauf von einigen Wochen schön ausgebildete, grosse rhombische Plättchen, die stark doppelbrechend sind und alle charakteristischen Merkmale der Eiweisstoffe besitzen. In grösserer Menge erhält man solche Kristalle aus der Fraktion, die mit Ammoniumsulfat zwischen 60—80% Sättigung ausfällt. Schon nach einigen Tagen erschienen zuerst immer mehr wachsende Nädelchen, die schliesslich die Form von sehr langen (bis 3 mm) stumpfen Stäbchen annahmen. Ausserdem erschienen nach einigen weiteren Wochen die mir schon bekannten rhombischen Plättchen. Das Verhalten dieser beiden Arten von Kristallen deutet auf das Vorliegen von zwei verschiedenen Eiweissubstanzen hin. Ich möchte den Versuch, der in bezug auf die Gewinnung verschiedener Kristallformen besonders erfolgreich war, hier genauer beschreiben.

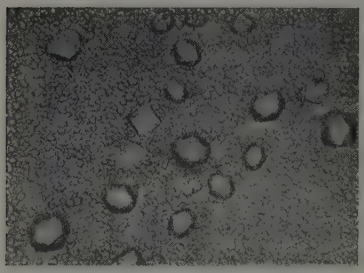

Abb. 1. Myogen A aus Menschenmuskel.

2. 1 kg Muskel aus frischer Leiche wurde in der Fleischmühle zerkleinert, mit 2.1 l eisgekühltem Wasser verrieben und nach 40 Min. in einem Leinensack ausgepresst. Der Auszug (2.1 l) wurde in drei gleiche Portionen geteilt und als I, II und III bezeichnet. Die Portion I und II wurden je mit 210 g von Ammoniumsulfat versetzt, die Portion III wurde vorher 20 Stunden lang dialysiert. Das Abfiltrieren von Niederschlägen dauerte 24 Stunden; zu den klaren Filtraten wurden je 100 g von Ammoniumsulfat zugesetzt. Die Niederschläge wurden gesammelt, das Filtrat aus der Portion I und II zusammengegossen und als IV bezeichnet. Die Niederschläge wurden in Wasser gelöst, 15 Min. bis 52° erwärmt und von dem koagulierten Eiweiss abfiltriert. Das nichtdenaturierte Eiweiss wurde aus allen drei Filtraten mit Ammoniumsulfat ausgesalzt und auf dem Buchnerschen Trichter abgesaugt. Der Niederschlag I wurde in 12 cm³ Wasser gelöst und mit Ammoniumsulfat bis zur ersten Trübung versetzt. Nach einigen Minuten fiel schon bei Zimmertemperatur ein kristalliner Niederschlag aus, in welchem sich die Kristalle von dodekaedrischem Typus befanden. Nach dem Stehen im Eisschrank vermehrte sich der Niederschlag bedeutend. Der Niederschlag II wurde in genau derselben Weise behandelt, die Kristallisation folgte aber erst nach einigen Tagen. Es erschienen kleine Stäbchen, welche

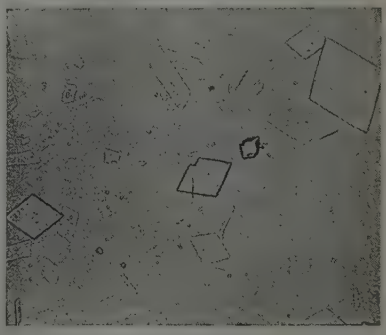

Abb. 2. Myogen B aus Menschenmuskel (in der Mitte ein Myogen-A-Kristall).

nach genauer Betrachtung sich als die in die Länge gezogene Modifikation der dodekaedrischen Kristalle erwiesen. Die Portion III, welche der Dialyse unterworfen wurde, lieferte schon nach einigen Stunden Stehen im Eisschrank eine beträchtliche Menge von Kristallen. Diese Kristalle hatten die typische, dodekaedrische Form.

Die Fraktion IV wurde mit 200 g Ammoniumsulfat versetzt, der Niederschlag gesammelt, das Filtrat mit V bezeichnet. Der Niederschlag IV entsprach der Fraktion, die zwischen 60—80% Sättigung mit Ammoniumsulfat ausfällt. Der Niederschlag IV wurde in Wasser gelöst, auf 52° erwärmt und auf die übliche Weise behandelt. Das Endvolumen der Eiweisslösung betrug 10 cm^3. Nach einigen Tagen erschienen zuerst immer mehr wachsende Nädelchen, die schliesslich die Form von sehr langen (bis 3 mm), stumpfen Stäbchen annahmen. Ausserdem erschienen nach einigen Wochen schon vorher beobachtete, rhombische Plättchen. Das Verhalten dieser beiden Arten von

Abb. 3. Myogen C aus Menschenmuskel.

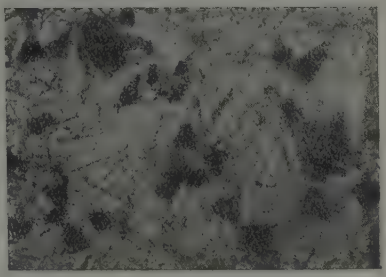

Abb. 4. Menschliches Myoglobin.

Kristallen wies auf das Vorliegen von zwei verschiedenen Eiweissubstanzen hin. Dieses Präparat wurde 6 Monate lang im Eisschrank sich selbst überlassen. Als ich nach dieser Zeit die Kristalle abzentrifugierte, stellte ich fest, dass sich 3 Schichten gebildet haben. Zuunterst befanden sich einige rhombische Plättchen, von fast ein halbes Zentimeter Durchmesser und 1—2 mm Dicke, und einige hunderte von kleineren Kristallen, welche doch einen Durchmesser von 1—2 mm besassen. Diese riesigen Proteinkristalle sind gelb gefärbt, besitzen eine gallertartige Konsistenz und lassen sich auf sehr dünne Glasnadel aufspiessen, obwohl sie härter sind als die Kristalle von Myogen A des Kaninchens. Im Wasser quellen sie vor der Auflösung auf. Unter leichtem Druck zerfallen sie in kristalline Splitter. Ich nannte dieses Protein provisorisch Myogen B (Abb. 2). Die mittlere Schicht der abzentrifugierten Kristalle enthielt zwei Typen von Kristallen: rhombische Plättchen von Myogen B von mittlerer Grösse und sehr viele lange Stäbchen provisorisch als Myogen C genannt (Abb. 3). Die dritte, obere Schicht bestand ausschliesslich aus kleinen Stäbchen. Die Lösung V, welche nach dem Trennen der Fraktion IV übrig blieb, wurde mit Ammoniumsulfat bis 96% Sättigung versetzt und nach dem Abfiltrieren des amorphen Niederschlages bei Zimmertemperatur einige Tage stehen gelassen. Nach dieser Zeit fiel ein braungefärbter, kristalliner Niederschlag aus, auch auf den Wänden des Gefässes wurden Bündel von Kristallen beobachtet. Unter dem Mikroskop erschienen diese als dünne, gelblich gefärbte Nädelchen, die häufig in Rosetten oder Bündel sich sammelten (Abb. 4). Diese Kristalle lösten sich in Wasser mit dunkelbrauner Farbe und zeigten die Eigenschaften der Proteine. Die nähere Untersuchung der Lösung zeigte, dass es sich um menschliches Myoglobin handelt, welches in diesen Bedingungen wahrscheinlich als Methmyo-

globin auskristallisierte. Durch Reduktion mit Natriumhydrosulfit tritt eine kirschrote Färbung auf und das Spektrum des Myoglobins. Es ist die Erstdarstellung des menschlichen Myoglobins. Die Kristalle sind in ihrer Form mit denen identisch, die aus Pferdeherz im Jahre 1932 von Theorell (2) dargestellt wurden, allerdings die Bedingungen, nach denen sie von mir erhalten wurden, sind viel einfacher. Eine ähnliche Vorschrift wurde vor kurzem von Roche (3) für das Pferdemuskelmyoglobin ausgearbeitet.

Die Versuche über die Eigenschaften der einzelnen, aus Menschenmuskel erhaltenen Proteine sind im Gange.

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ZITIERTE LITERATUR

[1] T. Baranowski, Biochimia, 5, 174 (1940). [2] A. Theorell, Bioch. ZS., 252, 1 (1932). [3] J. Roche et H. Vieil, C. R., 210, 314 (1940).

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GEOLOGY

A FINDING OF A GARNET GNEISS BOULDER IN THE COAL SEAM K_7 OF THE SERIES C_2^5 OF THE DONETZ BASIN

By G. F. TURLEY

(Communicated by P. I. Stepanov, Member of the Academy, 24.I.1941)

Inclusions in coal in the form of rock boulders foreign to the local geological structure have long been reported from European and American coal basins.

M. D. Zalessky (1) was the first to describe boulders from the Donetz coal basin. He emphasized the high scientific interest offered by the presence of these boulders in coal seams and pointed to the necessity of a study of the boulders in order to throw light upon the paleogeography of the coal basin, the mode of accumulation of the initial substance of coal and its formation. According to G. Potonje (6), the presence of boulders in coal is observed chiefly in parallic stone-coal basins, the boulders being one of the characteristical features of allochthonic coal accumulation. Unfortunately, so far only four cases of boulder findings in the coal seams of the Donetz basin have been reported in geological literature. M. D. Zalessky (1) has described two boulders: a rock boulder consisting of products of granite disintegration in the Kalmius seam (seam h_4 of the C_2^3 series) from the mine near the station of Mushketovo; boulders of quartz sandstone (weighing about 7 kg) from the seam «Kuzyi» (seam m_5 of the series C_3^1) in the Gorlovka region. N. K. Leshchenko (3) reported of two boulders: a plagioaplite and an arkose found in the dumps of mine No. 5 in the Stalin region, where the Livny seam is worked (h_{10} of the series C_2^5). In the present paper there is described a new finding of a garnet gneiss boulder in a coal seam of the Donetz basin.

The basin under description was found in autumn 1939, in the coal seam K_7 (Alexandrovsky) of series C_2^5, in the course of working in 346 horizon of the «Yunyi Kommunar» mine, the Ordzhonikidze region, in the western part of the Main Donetz anticline. It has been passed over to the author by P. I. Kudryavzev, student of the Industrial Academy in Kharkov. The series C_2^5 within the «Yunyi Kommunar» mine area is composed chiefly of sandstones, arenaceous schists, clayey shales, limestones and coal seams (2).

The boulder is oval in shape and of considerable size ($31 \times 23 \times 17$ cm), weighing 19.2 kg. According to the data available (7), a boulder of such a size has never been encountered in the Donetz basin. Its surface shows traces of intense wearing and is covered with a thin coal crust; fracture fine-grained, greyish-black colour with a faintly developed schistosity; specific gravity 2.8.

A microscopic study of the boulder made by V. I. Luchizky* in the Laboratory of Experimental Petrography of the Academy of Sciences of the USSR allowed us to make a determination of its petrographic composition. The chief minerals are: quartz with grains irregularly elongated following the lamination and considerably cataclastic; feldspar, intensely kaolinized and sericitized, also of irregular shape; in individual bands garnet is present in considerable quantities, in small irregular isometric grains, usually surrounded with a shell of disintegration products. Grains of colourless garnet are distributed individually or in groups; they are sharply idiomorphous with regard to quartz and feldspar. Some small scales, evidently of graphite, are observed. An abundance of ore-mineral grains: pyrite and haematite. The structure of the rock is banded. The rock is a garnet gneiss with graphite.

From its petrographic character the rock under description closely resembles those of the Teterevo-Bugh series (pre-Cambrian) of the Mariupol-Ossipenko region, and therefore it may be presumed that the primary deposit of the rock, encountered in the shape of a boulder in the seam K_7, is located South from the Donetz basin, in the eastern part of the Ukraine Crystalline platform, which is evidently the chief area of accumulation of clastic material, at the expense of which the coal-bearing deposits of the Donetz basin had accumulated.

As to the way by which the boulders penetrated into the coal seam, it may be said that considering the location of the primary outcrops of garnet gneiss (e. g. in the Berda river basin of the Mariupol-Ossipenko massif) at a distance of 80 km from the «Yunyi Kommunar» mine, they might possibly have been transported into the stone-coal lagoon (where the K_7 seam was deposited) by a river flowing from the South-West, together with vegetable material, probably in tree roots.

The authors find such an explanation to be quite concordant with the existing hypothesis as to the part played by rivers in the accumulation of coal-bearing beds of the Donetz basin ([5],[8]).

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REFERENCES

[1] М. Д. Залесский, Очерк по вопросу о происхожд. угля (1914). [2] В. И. Соколов, Геол. вест. (1915). [3] Н. К. Лещенко, Зап. Екат. н.-и. кафедры геологии (1926). [4] П. И. Степанов, Геология м-ний ископаемых углей (1929). [5] П. И. Степанов, Большой Донбасс (1932). [6] Г. Потонье, Происхожд. кам. угля и др. каустобиолитов (1934); R. H. Price, Jrnl. of Geol., XI, No. 1 (1932). [7] Ю. А. Жемчужников, Общая геология каустобиолитов (1935). [8] Д. В. Наливкин, Учение о фациях.

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* The writer avails of this opportunity to express his thanks to V. I. Luchizky.

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GEOLOGY

ON THE AGE OF LOVOZERO TUNDRAS

By E. K. HERLING, L. V. KOMLEV, K. N. SOKOLOVA and V. G. BARKAN

(Communicated by V. G. Chlopin, Member of the Academy, 24.I.1941)

In our previous communication (1) the mineral loparite (radioactive niobotitanate of rare earths, belonging to the perovskite group) was reported to have been found appropriate for precise age determinations by the helium method. Herling (2) has shown the physical properties of the crystalline lattice of loparite to be responsible for complete conservation of helium, which was formed in it during the process of radioactive decay. Close packing of the crystalline lattice of loparite and absence of cleavage practically prevent the diffusion of helium from the mineral.

Loparite from pegmatite veins of Chibiny tundras permitted the age of the Chibiny massif to be determined with great precision as equal to 280×10^6 years. A comparison of this figure against the well-known geological timescale of the American Committee for Geological Time Measurement (3) enabled us to refer the time of formation of the Chibiny massif to the Upper Devonian or Lower Carboniferous.

Determination of the age of the Lovozero alkaline plutone presented still greater interest. Within the last years geologists A. V. Vanidovskaya and S. D. Pokrovsky (4) succeeded in finding in xenoliths of sedimentary rocks of the roof plant remains referred by A. N. Krishtofovich (5) to the Upper Devonian.

Two loparite specimens of various genetic types were taken for age determinations. One of them consisted of an accumulation of well-developed loparite crystals up to 2 mm in diameter, associated with a small pegmatite vein in the foyalites of Alluaiv; the specimen, unfortunately, was not very fresh, being picked in all probability on the exposure surface. An inclusion of foreign minerals was ascertained in the microsection. The second specimen of loparite malinite from the drift No. 2 of the Alluaiv mine contained about 20% of very small fresh crystals of homogeneous loparite. Age determinations were carried upon the loparite concentrate separated by methylene iodide and containing about 45% of loparite; the rest consisted of aegirine whose radioactivity was known to be very small, as compared to that of the loparite, and could be disregarded.

The results obtained in testing these specimens for their helium, thorium and uranium content are reported below along with the respective age values. The values for the Chibiny loparite are also given for the sake of comparison.

Specimens	Helium content in mg	Thorium content in g	Uranium content in g	Age 10^6 years
Loparite from the pegmatite vein of Alluaiv	0.0564	7.05×10^{-3}	2.4×10^{-4}	231
Loparite concentrate from the malinite of the Alluaiv mine	0.0274	2.96×10^{-3}	1.1×10^{-4}	266
Loparite from Chibiny	0.0865	8.75×10^{-3}	3.6×10^{-4}	280

All of these are mean values of a series of parallel determinations agreeing with one another. The age calculations were made according to the formula of A. Holmes:

$$T = \frac{\text{He}}{\text{U} + 0.27\ \text{Th}} 8.8 \times 10^6$$

It may be seen that the age of the Lovozero loparites was found to be somewhat lower than that of the Chibiny loparites. A 20% loss of helium from the specimen No. 1 is, perhaps, due to unfreshness of the tested material and presence of foreign inclusions which were ascertained in microsections of this mineral. Study of the process of helium diffusion from this mineral under various temperature conditions showed the helium loss to be stipulated by two factors: helium transport along the lattice and along distortions of the crystalline lattice. The heat of diffusion of helium was calculated from the curves representing the helium loss under various temperatures. In the case of helium transport along the lattice the heat of helium diffusion was found to be 33400 gm cal./gram atom. This figure coincided, within the limits of accuracy of determinations, with that found for pure and homogeneous crystals of the Chibiny loparite. A much smaller value for the heat of diffusion was obtained in the case of helium transport along distortions of the crystalline lattice.

Determinations carried upon the loparite concentrate gave the age value of 266×10^6 years, this being in good agreement (within the limits of accuracy of determinations) with the value found for the loparite of the Chibiny massif. This age value has no claim to finality and should be determined with greater precision upon a more fresh and, above all, upon a more homogeneous material. Further work in this field will be undertaken. A conclusion which can, however, be made at this juncture, and one agreeing with geological conceptions, too, is that the formation of the Lovozero and Chibiny massifs took place in the same epoch and was complete not later than the Lower Carboniferous.

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REFERENCES

[1] L. V. Komlev and E. K. Herling, C. R. Acad. Sci. URSS, XXVI, No. 9 (1940). [2] E. K. Herling, ibid., XXIV, No. 6 (1939). [3] Nature, 135, No. 3410 (1935). [4] Н. А. Елисеев, А. В. Ванидовская, С. Д. Покровский, А. С. Сахаров и В. А. Унксов, Пробл. сов. геологии, 4 (1937). [5] A. N. Krishtofovich, Bull. Acad. Sci. URSS, sér. géol., 4 (1937). [6] Н. А. Елисеев и Н. К. Нефедов, Производит. силы Кольского полуострова. Лопаритовые м-ния Луяврурта (1940).

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GEOLOGY

ON STRATIFICATION AND A LAW OF SEDIMENTATION OF CLASTIC DEPOSITS

By V. P. BATURIN

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The formation of beds has recently invited the attention of a number of geologists-tectonists, who were quite right in including within the scope of their theoretical problems this highly interesting geological process which is most closely associated with oscillatory movements. However, leaving aside the conditions under which sedimentation took place and considering it only as a function of oscillatory movements, the tectonists restrict the problem of stratification, forgetting that the endogenetic forces of the earth do often but control the process of sedimentation, without participating in the formation of stratification.

Such a simplified approach to one of the most complicated processes highly responsive to the various geological phenomena taking place in all the three upper geospheres (lithosphere, hydrosphere and atmosphere), leads to an erroneous interpretation of the phenomena themselves and to an erroneous genetical treatment of the structural and textural characters of the rock. The present note is devoted to the analysis of the fundamental law of sedimentation of clastic deposits, which is of prime importance for the problem of stratification, since a sudden replacement of one sediment with a certain granulometric composition by another* ultimately results in a break in the process of deposition; and we will never be able to trace the origin of this break, unless our attention is focussed on the laws controlling the process as a whole.

The media of sedimentation are the atmosphere (we understand those portions of the earth's crust which are in contact with the atmosphere during the process of deposition) and the hydrosphere (the portions of the earth's crust which are in contact with the hydrosphere during the process of sedimentation); the media of transportation being the atmosphere, the hydrosphere in its liquid phase, and the hydrosphere in its solid phase.

The character of the sediment is determined by the peculiaritites of the medium of transport, which in their turn depend on the magnitude of the forces of the carrying agent $\left(\sum \frac{mv^2}{2}\right)$ when the latter passes into the medium of sedimentation. For the liquid phase the magnitude of the forces is

* We do not deal here with the stratification due in terrigene sediments to other causes, as colour, cement, etc.

determined by the final bottom velocity causing the fraction of sediments, as well as by the transverse component of the suspended particle.

The zones of sedimentation do not remain immobile either: from the littoral zone to the oceanic depressions the hydrosphere is in motion. At great depths the motion is hardly noticeable, near the shores the velocity obtains many meters per second. A considerable variation in the velocity is also observed in the zones of continental accumulation. Thus, the sedimentary material coming into the sedimentation basin does not, as a rule, preserve its granulometric composition, but changes in accordance with the amount of the carrying forces of the medium $\left(\sum \frac{mv^2}{2}\right)$, the magnitude of bottom velocities and the transverse components.

Thoulet's work in South Atlantics, Nansen's expedition in the northern part of the Atlantic Ocean, and M. V. Klenova's expedition in the Arctic seas gave a brilliant confirmation of the connexion between the granulometric composition of the sediments and the relief of the bottom and the dynamic conditions. The statements made by some tectonists as to a direct relationship between the nature of the sediment and the distance from the shoreline are based evidently on their ignorance of the results of modern investigation in the domain of marine geology.

In spite of the progressive movements, a part of the sediment in the medium of sedimentation perpetuallly or intermittently passes out of the mobile zone and is buried as an already formed rock. Thus, the final composition of the sediment buried will be determined not only by the rate of motion of the medium, but also by the time (t) during which the sediment remains under its influence. If this time be sufficiently long, the hydraulic value of all the particles will attain an equilibrium with the hydrodynamics of the medium. Thus, for instance, along the western shore of the Caspian Sea there are belts with depths of 10—15 m, occupied by sands, 90—95% of which are composed of particles 0.05—0.1 mm large.

Under these conditions the initial material does not affect the ratio of fraction in the sediments. This is confirmed by the absence of microlamination among the littoral deposits even in the deltaic zone, where the periodical shifting of the mechanical composition of sediments is clearly expressed. The Volga, for instance, carries during summer considerably more argillaceous alluvium than during flood; at the seashore, however, homogeneous silty sediments are deposited. No microlamination is observed either in the cores up to 1 m long, taken at different depths of the Caspian Sea.

In case the carrying forces of the medium of transportation are greater than those of the medium of sedimentation, the initial material is only partly deformed by the medium of sedimentation. If the influence of the medium of sedimentation upon the clastic material is of short duration, the original granulometric composition of the latter is changed little if at all.

Let us imagine a mountain stream with a rapid current discharging into a calm bay. The coarse material carried by the stream will certainly be only more or less completely redistributed in the zone of sedimentation. This may be exemplified by sedimentation in Polar seas, where large boulders, transported by floating ice, are brought into finely dispersed mud. In both cases large fragments reflect the dynamic factor of the medium of transportation and are in disharmony with the dynamics of the medium of sedimentation.

Particularly great is the influence both of the dynamic factor of the medium of transportation and the original granulometric composition of the transported products upon the composition of the deposits under conditions

of continental sedimentation, where the original granulometric composition is but slightly affected by the medium of sedimentation.

The above data and considerations allow us to suggest the following formulation of the law governing the influence of the three fundamental factors: the hydrodynamic factor of the medium of sedimentation (D), the hydrodynamic factor of the medium of transportation (d) and the granulometric composition of the initial products (g) upon the granulometric composition of the sediment (G). If the carrying forces of the medium of sedimentation are greater than those of the medium of transportation, both the distribution of the initial clastic products and the formation of some or other sediments depend only on the hydrodynamic factor of the medium of sedimentation, $G = F(D)$; in case of a reverse relation of the carrying forces, the initial material is but partly differentiated in the medium of sedimentation. $G = F(D,d,g)$. If the carrying forces of the medium of sedimentation are very small, while the time of their influence approaches zero, the granulometric composition of the sediment depends upon the hydrodynamic factor of the medium of transport and the granulometric composition of the initial products, $G = F(d,g)$.

In this form the law of sedimentation of clastic material is applicable to particles not subject to coagulation, i. e. larger than 0.01—0.02 mm. The granulometric composition of finely dispersed coagulated sediments is in no perfect agreement with this law, sedimentation being governed also by the laws of colloidal chemistry (in the course of coagulation the particles may grow larger).

At the first sight at the equation of sedimentation, one part of which is represented by the dynamic factor, and the other by the granulometric composition, it may seem that both are simple enough and their relation is well known. As a matter of fact, it demands the most serious attention and requires still a thorough analysis, especially if we consider the process of sedimentation under an historical aspect and search for the causality of stratification.

After having found the relation between the granulometric character of the sediment and the hydrodynamic factor, we closely approach the problem of stratification in clastic deposits, i. e. the mechanism of the break, which results in an abrupt change in the size of grains. All the above shows that this break may be caused only by a sharp change in the hydrodynamic factor and our analysis should be concentrated upon the causes affecting the dynamics of the basin (we do not consider here sedimentation in an aerial medium).

According to the character of the dynamic factor, four zones may be isolated in aqueous basins: a perpetually mobile, an episodicallly mobile, a slightly mobile and a zone of bottom currents; the latter may overlap the three first zones. These follow one another in succession off shore, though there are many exceptions to this rule.

The mobile zone occupies the shallow water, where the other zones are less frequently observed. Even the slightest motion of water is transmitted here to the bottom of the sea (it is to be remembered that the depth of wave propagation is about equal to their length), and therefore the sediment is for the most part in motion.

The clastic material brought into the basin of sedimentation passes usually into the first zone, where a perpetual stirring of the material takes place. The suspension is precipitated according to Stokes and Rettingher's laws. In the course of sedimentation, however, a horizontal shifting of small grains takes place from mobile zones to the less mobile ones. The slower the rate of falling of the particle, the greater may be its shift in a horizontal direction.

On the other hand, the greater the number of stirring, i. e. the longer the sediment remains in the medium of sedimentation, the less is the number of remaining particles whose hydraulic value does not correspond to the rate of motion of the medium. Thus, sands homogeneous as to their granulometric composition with a grain size corresponding to the rate of motion of the given area are formed in the mobile zone.

The episodically mobile zone is characterized by an accumulation of small particles only, supplied from the first zone, but during storms the bottom waves bring also silty and sandy material and disturb the previously deposited sediment. This leads to the formation of an arenaceous or silty layer among muddy deposits*.

The sligthly mobile zone remains unaffected even by stormy waves, and it is only in the case of currents that some motion is produced near the bottom. The streams may complicate the dynamic conditions of the former two zones, too.

Aside from the depths, the force of a rolling sea depends on the rate of the wind and the size of the aqueous basin** (the propagation of waves). The works by Nansen, Archangelsky and others show that the rôle played by sea currents in the alteration of the composition of rocks is very great.

Let us consider whether all these facts determining the hydrodynamic conditions, are due exclusively to oscillatory movements. Such a dependence is inquestionable for many factors, but we will not dwell upon this, since at present we are interested in those cases where such a dependence does not exist. Even variation in depth is not always connected with oscillatory movements. In all closed basins, that had been of wide occurrence in the geological past, the depth is frequently determined by climatic conditions, of which the Caspian Sea is an excellent example.

The alterations of the area of sea basins are certainly first of all produced by transgressions and regressions, i. e. connected with oscillatory movements; of no less importance are also the accumulation and erosion processes which may widen or restrict water areas. Sharp changes in the area of water basins took place during the Glacial period; suffice to note the blocking of the North Sea by ice from the North, the widening of the Caspian Sea during the thawing of the glacier and so on.

The decisive part played by climatic factors in the regime of aerial and sea currents responsible for the mobility of the aqueous and aerial envelops is beyond any doubt, and the changes in the granulometric composition which correspond to these phenomena should therefore be regarded as exogenetic.

According to the law of sedimentation formulated by us, in the general case $G=F(D)$, but D in its turn depends on a number of variables, among these also on oscillatory movements, $D=F(a, b, c \ldots . k)$. This complicated functional relation shows that the phenomenon of break may be connected, besides oscillatory movements, with a number of other exogenetic phenomena as well. An analysis of the stratification of fossil sediments will enable us to disclose many of these exogenetic processes in the geological past.

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* Such a type of stratification has been as yet insufficiently studied; it is probably characteristic of mean and great depths of shelves of open seas where the rolling of the sea is very vigorous and sometimes penetrates to a great depth. In the author's conception such a stratification (stormy texture) played a considerable part in the formation of the flysch.

** In the Azov Sea the sands do not descend below 4 m, in the Caspian Sea, according to our investigations, sands are encountered at a depth of 15 m. In the open sea near the Falkland islands sands and gravel occupy extensive areas 200 m deep.

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GEOLOGY

ON THE AGE OF CARBONIFEROUS DEPOSITS OF THE ISACHKY ELEVATION REGION

By D. E. AISENVERG, N. E. BRAŽNIKOVA, E. O. NOVIK and P. L. SHOULGA

(Communicated by P. I. Stepanov, Member of the Academy, 24.I.1941)

In June 1940 we obtained a collection of fauna from Carboniferous deposits of the Isachky borehole No. 9. The latter is situated on the southern wing of the Isachky elevation*. Carboniferous deposits were met at a depth of 315.00 m, but the layers containing fauna were found between 349.30 and 385.70 m.

The study of the above-mentioned fauna made by the authors gave the following results:

1) 345.65—349.30 m. Grey sandstone, fine-grained, somewhat calcareous. With appendices of *Stigmaria ficoides* Sternb.

2) 349.30—353.70 m. Grey, tough limestone, with fissures containing: *Hyperammina vulgaris* Raus. et Reit., *Glomospira* sp., *Archaediscus karreri* Brady, *Archaediscus* sp., *Endothyra parva* Möll., *Endothyra* ex gr. *bowmani* Phil., *Endothyra* ex gr. *crassa* Brady, *Endothyra* sp., *Tetrataxis minima* Lee et Chen., *Staffella* (*Parastaffella*) ex gr. *struvei* Möll., *Staffella* (*Eostaffella*) *pseudostruvei* Raus. et Reit., *Productus* (*Gigantella*) cf. *latissimus* Sov. var. *prisca* Sar.

3) 365.50—380.15 m. Black fine-grained shale, irregularly bedded and with a great quantity of sliding surfaces. Determined: *Amusium concentricum* Hall., *Pseudomusium ellipticum* Phil., *Nucula luciniformis* Phill., *Aviculopecten dissimilis* Flem., *Aviculopecten deornatus* Phill., *Mytilus* aff. *flemingi* M'Coy, *Entolium* sp., *Chonetes* (*Paeckelmannia*) aff. *Schmiereri* Paeck., *Chonetes* (*Chonetes*) *laguessianus* Kon. emend. Paek., *Chonetes* (*Chonetes*) aff. *shumardianus* Kon., *Chonetes* (*Chonetes*) cf. *dalmanianus* Kon., *Productus* (*Marginifera*) cf. *longispinus* Sow. emend. Muir-Wood., *Athyris* (*Actinoconchus*) cf. *planosulcata* Phill., *Athyris* sp., *Ambocoelia* aff. *urii* Flem., *Retzia*? *radialis* Phill.

4) 380.15—382.00 m. Grey, tough limestone. Determined: *Hyperammina vulgaris* Raus. et Reit., *Hyperammina elegans* Raus. et Reit., *Glomospira* sp., *Ammodiscus* sp.. *Archaediscus karreri* Brady, *Archaediscus* ex gr. *baschkiricus* Krest. et Teod., *Endothyra bowmani* Phill., *Endothyra crassa* var. *compressa* Raus. et Reit., *Endothyra similis* Raus. et Reit., *Endothyra prisca* Raus. et Reit., *Endothyra parva* Möll., *Endothyra* sp., *Tetrataxis conica* var. *gibba* Möll., *Cribrostomum bradyi* Möll., *Pr.* (*Gigantella*) *latissimus* Sow.

* V. Isachky, about 20 km from Lubny, Ukrainian SSR.

5) 382.00—383.50 m. Dark-grey shale with remains of *Syringopora* sp.

6) 383.50—384.90 m. Grey, tough, a little flinty limestone. Determined: *Hyperammina vulgaris* Raus. et Reit., *Glomospira* sp., *Ammodiscus* sp., *Archaediscus karreri* Brady, *Archaediscus* ex gr. *baschkiricus* Krest. et Teod., *Endothyra bowmani* Phill., *Endothyra* sp., *Tetrataxis conica* var. *gibba* Möll., *Pr.* (*Gigantella*) sp. ind.

After having considered the vertical range of the above-mentioned species, it becomes obvious that the rocks containing this fauna are to be referred to the Lower Carboniferous. Some species which show a wider vertical range, such as *Endothyra bowmani* Phill., *Cribrostomum bradyi* Möll., *Athyris* (*Actinoconchus*) *planosulcata* Phill., or those which have not been sufficiently studied, as *Endothyra parva* Möll., *Ambocoelia urii* Flem., *Retzia radialis* Phill., do not change our conception. It is noticeable, that Tournai forms are only few in number. The considerable amount of Visean foraminiferae (*Hyperammina vulgaris* Raus. et Reit., *H. elegans* Raus. et Reit., *Archaediscus karreri* Brady, *Endothyra* ex gr. *crassa* Brady, *E. prisca* Raus. et Reit., *E. similis* Raus. et Reit., *Tetrataxis conica* var. *gibba* Möll.), the presence of representants of the group *Productus* (*Gigantella*) *latissimus* Sow., with a fragment of thick-valved shell from the same group, *Productus* (*Gigantella*) sp. ind., in spite of the presence of a series of Lower Namur forms—some foraminiferae [*Archaediscus baschkiricus* Krest. et Teod., *Staffella* (*Eostaffella*) *pseudostruvei* Raus. et Reit.], confirms the identity of the said deposits with the Vise stage.

Most probably this series of rocks belongs to the *Dibunophyllum* zone of the Anglo-Belgian basin, upper Okskian series of the Moskow basin, or series $C_1^V f$ (after A. P. Rotay) of the Donetz basin Lower Carboniferous.

To conclude, it may be added that in the borehole No. 10 bis situated at a 150 m distance North from the borehole No. 9, quite recently a limestone was met at a depth of 325.19 m, in which N. E. Bražnikova has identified the following species: *Hyperammina vulgaris* Raus. et Reit., *Hyperammina* cf. *elegans* Raus. et Reit., *Glomospira* sp., *Ammodiscus* sp., *Archaediscus karreri* Brady, *Archaediscus* sp., *Endothyra bowmani* Phill., *Endothyra prisca* Raus. et Reit., *Endothyra parva* Möll., *Endothyra* ex gr. *crassa* Brady, *Endothyra* sp., *Tetrataxis conica* var. *gibba* Möll.

This finding goes to confirm the Visean age of the rocks. In the limestone from the borehole No. 11, 1.5 km West from the No. 9, some isolated specimens of *Endothyra* sp. and *Archaediscus* sp. have been met with, which also testifies to the presence of deposits of the Visean (or Namur) stage in this district.

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GEOLOGY

CAMBRIAN CARBONATE DEPOSITS OF THE USSIN-TOMSK WATERSHED OF THE KUZNETSK ALATAU

By A. L. DODIN

(Communicated by P. I. Stepanov, Member of the Academy, 24.I.1941)

While carrying out in summer 1939 a geological survey of the Ussin region, the author of the present paper succeeded in determining the age of the most ancient carbonate deposits of this part of the Kuznetsk Alatau.

To the present time the age and structure of ancient carbonate deposits of the Kuznetsk Alatau have been a matter of considerable controversy, one and the same deposit being referred by different investigators to Cambrian, Proterozoic and Archaean. The most correct estimation appears to have been given by D. V. Nikitin who referred the crystalline limestones to Cambrian. A discovery of archeocyathes in marmorized limestones enabled the author of the present paper to solve the fundamental problem of the age and tectonics of ancient deposits in the southern part of the Kuznetsk Alatau.

These deposits build up the core of a big anticlinal fold traced at a distance of over 50 km from the river Belaya Ussa in the North to the river Belsu in the South. Beds of the carbonate series strike nearly in the meridional direction and dip East and West under steep angles up to 90°. The series under consideration is represented lithologically (in ascending order) by light-grey and dark marbles, marmorized and dolomitic limestones with separate packs of argillaceous siliceous shales. Their thickness increases southward, and there appear graphitized shales with separate graphite lenses. Paleontological evidences were found by us on a weathered surface of marmorized limestones building up the upper portion of the core of the Ussin anticlinal fold, well exposed in the region of the Ivanov mine, near the confluence of the rivers Chernaya and Belaya Ussa.

Among the collected archeocyathes A. G. Vologdin identified the following: *Labyrinthomorpha* sp. (*Lab. tolli* Vologd.), *Protopharetra* cf. *spelunca* Vologd., *Protopharetra* sp., *Tersia* sp. (*Tersia filiformis* Vologd.?), *Spirocyathus* sp., *Archaeocyathus* cf. *tomicus* Vologd., *Archaeocyathus* sp., *Loculocyathus* sp., *Asterocyathus* cf. *longus* Vologd., *Coscinocyathus* aff. *howelli* Vologd., *Coscinocyathus* sp. 1, *Coscinocyathus* sp. 2, *Rhabdocyathus* sp. nov. Together with archeocyathes there were also collected thread-like reef-building algae, among which Vologdin identified *Epiphyton grande* Gordon, *Ep. fruticosum* Vologd., *Ep. Bublitcsenkovi* Vologd., common form *Ep. fasciculatum* Chapm., and also *Renalcis* sp., *Chabakovia* sp.

This complex of algae is typical, according to Vologdin, of the Middle Cambrian. The most characteristic forms of archeocyathes are *Asterocyathus* cf. *longus*, discovered in the Gavrilov series of limestones (Salair), and *Coscinocyathus* aff. *howelli*, which can be aligned with a form from upper parts of the Torgashin series. *Labyrinthomorpha* sp. closely resembles both *Problematica*, established by E. Toll in the Torgashin limestone, and *Labyrinthomorpha tolli* Vologd., established by A. Vologdin in the Kameshki

limestone. Therefore, the fauna and flora described above are highly indicative of a transitory age of the limestones under consideration, from the Lower to Middle Cambrian. In all probability their age may be referred to lower horizons of Middle Cambrian.

This series of archeocyathic limestones of Middle Cambrian attains 900 m in thickness, being conformably underlain by marbles and strongly dolomitic limestones with siliceous partings, which may be, perhaps, referred to upper horizons of Lower Cambrian. Dykes of Labrador porphyrite occur among marbles and archeocyathic limestones. Above the archeocyathic limestone there rests a pinky violet calcareous conglomerate grading upwards into pinky calcareous sandstones, shales and tuffs. The thickness of this red-coloured conglomerate-arenaceous series is estimated at 400—500 m.

The carbonate deposits of the Ussin region, described above, are of considerable practical value, since a known manganese mineralization has been found to be associated with them.

The highest manganese concentration is observed in the vicinity of the Ivanov mine on the right bank of the river Ussa. The manganese ore-body of the Ivanov deposit possesses the form of a lens, resting among archeocyathic limestones of the eastern anticlinal limb. This ore-lens pinches out a distance of 1 km in the direction of its strike, whereas across the strike manganese oxide ores have been traced in the central part of the lens at a distance of 120—150 m. Dense siliceous-carbonate rocks alternating with poor carbonate ores and barren limestones constitute the main ore-body. The Mn content in rich siliceous-carbonate rocks varies from 20 to 30% and in poor carbonate ores from 2 to 7%. Prospecting (conducted under Mukhin's supervision) noticeably cuts down expected resources of the deposit estimated formerly by K. V. Radugin (1), but nevertheless corroborates the previously held opinion that the Ivanov deposit of siliceous-carbonate manganese ores is of great practical value, being able to satisfy the demand of the Kuznetsk Metallurgical Combinat in manganese. A discovery of separate ore-lenses north and south of the Ivanov deposit may be expected. In 1940 the second manganese mineralization was discovered by the author among marbles near the Isras mine located at a distance of 40 km south of the Ivanov deposit. This new place of manganese mineralization is of considerable interest, since it is located at a distance of only 7 km north of the river Tom valley, in which it has been planned to build a railroad line Stalinsk-Abakan. The mineralization is represented by separate concretions of manganese oxide ores (Mn content up to 59%) resting among marbles, which are exposed along the riv. Izras, and also by outcrops of washed oxides ore-beds, occurring in heads of steep layers of marbles in the region of the river Tomilovka. Separate packs of marbles are of pink hues and contain manganese, according to data of qualitative analysis.

The Cambrian carbonate deposits have been found to contain, besides the manganese mineralization, also graphitized shales with graphite lenses and ferruginous quartzites. Graphite lenses have been observed on the right bank of the river Belsu, 0.5 km above its inflow into the Kuyasu river.

In conclusion it should be pointed out that detailed prospecting for regions favouring the manganese mineralization is needed, in which special attention should be given to the transitional horizon from the Lower to Middle Cambrian, where carbonate deposits are represented in the reef facies and contain archeocyathes and algae described above.

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REFERENCES

1 К. В. Радугин, Вест. Зап.-Сиб. геол. управл., вып. 1 (1939).

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MINERALOGY

ON CADMIUM IN ORGANISMS

By D. P. MALYUGA

(Communicated by W. I. Vernadsky, Member of the Academy, 28.I.1941)

Cadmium, due to its insignificant content in the earth's crust*, does not form deposits of economic importance and is produced exclusively from zinc and other ores as a by-product. The zinc ores contain from 0.10% cadmium in zinc blende (ZnS) up to 5% in smithsonite (Spain) (2).

The informations at present available in the literature (3–11, 13) on the subject suggest that cadmium is very widespread in the lithosphere, although in very small amounts. So we have made some attempts at determining cadmium in certain soils, land plants, sea organisms, etc.

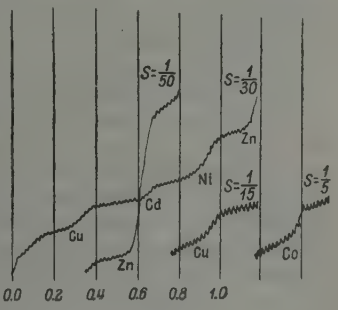

Fig. 1.

In determining cadmium we have used the previously developed method of a simultaneous polarographic determination of small amounts of copper, cadmium, nickel, zinc and cobalt in soils, natural waters and organisms. The highly favourable position of cadmium on the polarographic curve** when it precedes nickel, zinc and other elements, more widespread in nature, enables us without particular difficulty to obtain and measure its wave, corresponding to the value of the current for its deposition on the mercury drop cathode. This is well seen from the polarogram presented in Fig. 1 and obtained by us when determining cadmium in a sea alga—*Ascophyllum nodosum*.

In order to verify whether variations in the height of the waves, corresponding to the value of the «diffusion current of deposition», are proportional to the change of the cadmium concentration in the solution, we prepared a series of polarographic curves with various concentrations of cadmium in the solution tested within the range of from 0.0805 to 0.00966 mg in one cubic centimeter, and on the basis of the wave height values obtained the so-called calibration curve was plotted. Within the range of concentrations

* After A. E. Fersman (1) a weight clarke of cadmium in the earth's crust is 5.0×10^{-4} %.

** According to our determinations, the potential of the half-waves of electrolytic deposition of cadmium on the mercury drop cathode in the presence of NH_4Cl—0.02 *n* is $P=0.65$ V.

used, the curve obtained in the experiment and the theoretical one were overlapping, which was evidence of a full proportionality between the height of the wave and the cadmium concentration in the solution.

In order to compare the polarographic determination of cadmium in the material investigated with some other method, we made a simultaneous determination of this element in the bark of aspen (*Populus tremula* L.) by the colorimetric dithizon method according to H. Fischer ([12]). As a result of this determination, in the dry matter of the bark of aspen 1.6×10^{-4}% cadmium was found by the polarographic method, and 1.7×10^{-6}% by the colorimetric method. The discrepancy between the polarographic and the colorimetric data was equal to 6%.

Using the polarographic method, we made a number of determinations of cadmium along with determinations of nickel, zinc and cobalt in the most diverse material, namely: in soils, in natural waters, in some animals and plants. It was not always possible to discover cadmium, since the quantities of the samples had been calculated in the first place for a determination of nickel and cobalt, and were not always found to be sufficient for the determination of cadmium. However, in a number of cases we succeeded not only in discovering cadmium qualitatively, but also in determining its quantity. Thus, in the grey (serozem) steppe soil of the Terek-Kuma semidesert (Bakress sovkhoz), Dzerjinsk region, in the *D* horizon at a depth from 160—170 cm, 1.7×10^{-4}% cadmium was found, and in the chernozem steppe soils from serpentinites (*A* horizon from 0 to 5 cm) of the Akkerman nickel deposits (Orsk region)—4.5×10^{-3}%. In the same Akkerman section at a depth from 25 to 30 cm 1.6×10^{-3}% cadmium was found. In the latter case there is observed an inequality in the distribution of cadmium in the soil, according to horizons; this is like what we have established with regard to the other heavy metals—copper, nickel and cobalt—in the same section, namely a higher content of metals in the upper horizon and a considerably lower one at a depth of 25—30 cm and below. The zinc content in all of these cases exceeds the content of cadmium 20—30 times. In a number of other soils which we investigated no cadmium was discovered. When investigating the natural surface waters, cadmium was found only in one case—in the water of the Urov river.

As already noted, cadmium was also found in the bark of aspen in a quantity of 1.6×10^{-4}% calculated on the dry matter basis; in fir-needles*, in the ash of hemp and in some other land plants. The determination of zinc in the bark of aspen (dry matter) showed a content of 3.3×10^{-3}%, which is 20 times the cadmium content.

We have also investigated some sea organisms. It had already been known that cadmium is present in the organs of some sea animals ([7], [10], [13]). We were the first to determine cadmium quantitatively in whole sea organisms—in algae, etc. The data of our determinations are given in the table.

In all the sea organisms investigated cadmium was discovered, and in most cases determined quantitatively. The ratio between cadmium and zinc** in sea algae, with rare exceptions, is maintained as 1 : 20. Sometimes it approaches 1 : 5. At the same time in the starfish *Asterias rubens* this rate is equal to 1 : 80.

The latest data which are at our disposal with regard to the cadmium content in the live matter refer to its content in human organs. Thus, we have found that the kidneys of a sick person, who had died after a serious

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* The plants were collected in the Ostankino park (Moscow).

** Data on the content of copper, zinc, nickel and cobalt in sea organisms will be published by the author later.

Organism	Origin	Quantity of cadmium in the dry matter of the organism, %
Sea algae		
Fam. *Fucaceae*, *Fucus serratus*	Dalnie Zelentzy (Murmansk Biolog. Station. 1938)	3.4×10^{-5}
Fam. *Fucaceae*, *Ascophyllum nodosum*	Do	2.9×10^{-5}
Fam. *Fucaceae*, *Fucus inflatus*	Ekaterininsky harbour, Barents Sea, 1929	1.6×10^{-5}
Fam. *Laminariaceae*, *Allaria esculenta*	Dalnie Zelentzy	1.0×10^{-4}
Fam. *Laminariaceae*, *Phyllaria dermatodea*	Do	1.0×10^{-5}
Fam. *Laminariaceae*, *Laminaria saccharina*	Ekaterininsky harbour	1.4×10^{-5}
Sea flowering plants		
Fam. *Potamogetaceae*, *Lostera marina*	Do	2.3×10^{-5}
Sea animals		
Fam. *Gastropoda*, *Pecten islandicus*	Do	Traces
Fam. *Asteriidae*, *Asterias rubens*	Dalnie Zelentzy	1.1×10^{-4}
Fam. *Gadidae*, *Gadus collarius*	Do	Traces

poisoning with volatile organic lead components, contained 3.3×10^{-3}% cadmium in the raw matter. In the kidneys of another sick person, who had died from a heart disease, the Cd content was equal to 3.8×10^{-4}%, respectively. The quantity of zinc was 5—6 times that of cadmium. Along with this, cadmium was found in some other organs—in the spleen, in the lungs, etc.

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Received
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REFERENCES

[1] А. Е. Ферсман, Геохимия, IV (1939). [2] Schnabel, Handb. der Metallhüttenkunde, **2**, 318 (1904). [3] W. F. Hillebrand, Bull. U. S. Geol. Sur., **113**, 49 (1893). [4] В. И. Вернадский, История минералов земной коры, **2**, История природных вод, вып. 2, 318 (1934); вып. 3, 453 (1936). [5] E. Jensch, ZS. angew. Chem., **3**, 14 (1890). [6] M. Javillier et T. Richardson, Bull. Soc. Pharm., **15**, 129, 559 (1908). [7] H. Fox and H. Ramage, Nature, **126**, 682 (1930). [8] L. W. Gaddum, Proc. Fla. State Hort. Soc., 83 (1934). [9] E. Müller, Bioch. ZS., **286**, 182 (1936). [10] H. Ramage, Nature, **138**, 762 (1936). [11] А. П. Виноградов, Тр. Биогеохим. лабор., **4**, 159 (1937). [12] H. Fischer, Angew. Chem., No. 26, 442 (1933). [13] J. Noddack and W. Noddack, Ark. f. Zool., **32** A, № 4, 1(1939).

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MINERALOGY

GENETIC TYPES OF COBALT DEPOSITS IN THE URALS

By A. E. MALAKHOV

(Communicated by A. E. Fersman, Member of the Academy, 3.II.1941)

In a number of papers A. E. Fersman stresses the fact that among petrogenic and metallogenic elements cobalt occupies a definite geochemical position and plays a particular rôle in the triade iron-cobalt-nickel. Prospecting for new places of concentration of cobalt ores on the territory of the USSR should be conducted along the lines traced in these papers in analyzing some genetic examples ([1], [2]).

It is because those lines have been followed in research work that one has come of late to consider the Urals as an unquestionably rich cobaltiferous metallogenic province represented in a number of instances by somewhat peculiar genetic combinations. The most pronounced concentrations of cobalt ores in the Urals are met with in the following genetic varieties:

A) Deposits of the exogenetic group, in the first place widely distributed deposits of the Mesozoic weathering crust of the Southern and Middle Urals. The following types may be distinguished in this group:

1. A type of oxide (hydroxide) ores most frequently represented by cobaltiferous asbolites, a typical example (prototype) being the Elizavetin deposit. Cobalt and nickel (in the ratio 1 : 5) are contained in complicated complex hydroxides of iron, manganese, etc.

2. A silicate type, represented by various deposits. The Seversky group of deposits and others are characteristic of this type. Both cobalt and nickel in the ratio 1 : 20 enter an isomorphous row of hydrous magnesia silicates: revdiniskite, garnierite, etc.

B) Deposits of the endogenetic group which, being also sufficiently distributed, are represented by very peculiar parágenetic combinations. The following types possessing noticeable cobalt concentrations may be distinguished:

1. A silicate hypogenetic type in dunite plutones of the Urals, primarily in the most interesting Taguil dunite massif. Cobalt as well as nickel (in the ratio 1 : 10) enter isomorphously into the olivine row.

2. A sulphide type which has been shown of late to be present in a number of classical deposits of the Urals.

a) In contact-metasomatic copper and iron ore deposits: Turyin mines, Vysokaya, Magnitnaya Mts., etc.

b) In copper pyrite deposits of the Pyshmin-Kliuchevsk ore field ([3]), III International, Degtiarka, Ziuzelka, etc.

c) In hydrothermal iron-ore deposits, a typical example being the Kutim deposit in the Northern Urals, where cobalt is encountered in noticeable quantities in one of sulphide phases (Malakhov, 1940).

d) In a number of hydato- metamorphogenously altered rocks which are regionally distributed, in the first place in listvenites of the Pyshmin-Kliuchevsk ore field.

In all modifications of the sulphide type cobalt is endocryptously associated with pyrite, to a smaller extent with pyrrhotite and very rarely gives arsenides of the shmaltite, cobaltite and similar types.

A group of geologists of the Academy of Sciences (under I. I. Ginsburg's supervision) has subjected the exogenetic rocks (group A) to detailed examination and, consequently, these rocks are thoroughly characterized from the geochemical standpoint. On the other hand, deposits of the endogenetic group have been so far but little studied.

A study of new analytical data on the cobaltiferousness of numerous places of cobalt concentration in the Urals lead us to the belief that the sulphide hypogenetic formations (type B-2) offer the greatest possibilities of utilization, and among these the copperpolymetallic deposits of the Pyshmin-Kliuchevsk group and particularly listvenites of the Pyshmin-Kliuchevsk ore-field (only recently detected by us as an interesting source of the cobalt stuff) are of special value.

The last-named group of recently detected deposits displays certain peculiarities: close genetic association of cobalt with iron in pyrite and complete or nearly complete absence of the third element of the triade—nickel—in copper-sulphide cobaltiferous ores (including cobaltiferous listvenites). This hypogenetic antagonism of cobalt and nickel may be regarded as a certain regularity which, however, is not observed in the greatest similar sulphide deposit Tamiskeming (Canada).

Such a peculiar behaviour of cobalt with respect to nickel deserved to be examined closer. We believe that the rôle of arsenic in ore solutions is responsible, in the first approximation, for the separation of these two elements under hypogenetic conditions. A nearly complete absence of arsenic in the sulphide cobaltiferous deposits of the Urals brought about a different course of the process.

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Received
4.II.1941.

REFERENCES

[1] А. Е. Ферсман, Геохимия, IV, 144 (1939). [2] A. E. Fersman, Bull. Acad. Sci. URSS, sér. géol., No. 3, 7 (1939). [3] А. Е. Малахов, С. А. Вахромеев, Ф. П. Опарин и Ю. С. Соловьев, Пышминско-Ключевское полиметаллическое рудное поле, Монограф. описание, Свердловский горный институт (1939).

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STRATIGRAPHY

ON THE AGE OF THE UPPER PALEOZOIC DEPOSITS OF THE SOUTH-EASTERN PART OF THE KOLYMA BASIN

By B. K. LICHAREW and O. L. EINOR

(Communicated by P. I. Stepanov, Member of the Academy, 15.I.1941)

In 1934 one of the authors (2) made a monograph on the paleontological collections made by S. Obruchev during his expedition to the Yakut Autonomous Soviet Socialist Republic. The results of this work have shown that I. Tolmachev was wrong in determining the age of the Polovinny Kamen on the Kolyma river as Upper Devonian. The fauna collected from this exposure was referred by B. Licharew to the Permian, this being the age established likewise for the outcrops of the Upper Paleozoic in the region of the right hand tributaries of the Kolyma river, the rivers Omolon and Korkodon. In 1938 this conclusion was, however, questioned by M. Yanishewsky who described fauna from several other regions of the Upper Kolyma basin and identified it as Lower Carboniferous. Inasmuch as this fauna seemed to include many of the species described in the indicated work, M. Yanishewsky drew the conclusion that «not all what is referred by Licharew to the Permian, actually belongs to the latter; further detailed studies are no doubt required for a more accurate knowledge of the stratigraphy of the Upper Paleozoic deposits of the Kolyma land» (3).

In 1939 the authors obtained for monographic treatment paleontological material collected by a number of geological and prospecting parties on the Kolyma river and its right hand tributaries—the Omolon and Korkodon rivers (collections by L. Snyatkow, B. Snyatkov, V. Lebedev, A. Avramov, R. Sievert, P. Prokofiev, M. Gurski, F. Ilyin, F. Rabinovitch).

Our investigations enable us to confirm the conclusion of the geologists who delivered these collections, that in the regions concerned there exist both Lower Carboniferous and Permian formations. The brachiopod fauna of the Lower Carboniferous proved to be quite scanty; among them we succeeded in determining altogether no more than 15 forms, including such as *Leptaena analoga* Phill., *Chonetes* cf. *papilionacea* Phill., *Ch. dalmaniana* Kon., *Productus elegantulus* Tolm., *Pr.* cf. *plicatilis* Sow., *Spirifer ussiensis* Tolm. etc. It is noteworthy that among these Lower Carboniferous forms we practically failed to discover any North-American species, exactly those which were recorded as occurring in great numbers by Yanishewsky. Since certain forms are derived from various regions, they may, naturally, belong to various horizons of the Tournaisian or Visean stages. However, the absence of *Gigantella* and *Striatifera*, ranging widely in the Visean and Namurian,

speak rather in favour of a more ancient (not younger than the Lower Visean) age of the fauna. This determination of the age of the given deposits is in full accord with the conclusions arrived at by V. Fomichev, too, who determined collection of corals from the same deposits (found, however, mainly in no association with brachiopods).

Though the presence of Lower Carboniferous deposits in the Kolyma basin was thus fully confirmed by our investigations, M. Yanishewsky's opinion, cited above, was not borne out by any evidence—all the forms described by B. Licharew in 1934 actually proved to belong to the Permian. Of those we were able to determine and describe at present about 80 forms. All this quite abundant fauna comes from numerous exposures, however, none of the latter yielded any appreciable number of forms. Analysis of the distribution of the fauna throughout these exposures furnished no basis for establishing any separate horizons, and we were compelled to consider all the Permian beds as a whole. Leaving aside the forms already described by Licharew in 1934, we believe that the occurrence here of certain species new to the region under description would be worth mentioning.

Among *Productus* s. l. invite attention finds of *Pr. cancrini* Vern. (large specimens) and *Pr. verhoyannicus* Fred., the guide form of the Permian of Verkhoyansk. Very abundantly is represented the new species *Pr. korkodonensis* Lich., sp. n., approaching some of the figures of the Australian species *Pr. brachythaerus* Morr.

Of interest is the wide development among *Spirifer* of representatives of the subgenus *Licharewia*—five of our Zechstein species are represented here: *Sp. stuckenbergi* Netsch., *Sp. schrenki* Keys., *Sp.* cf. *grewingki* Netsch., *Sp.* cf. *lahuseni* Netsch. and *Sp. keyserlingi* Netsch. We lay particular stress on this fact, since M. Kulikov (1) recently expressed his doubts as to the correctness of determination of some of these forms from the Kolyma river and from Novaya Zemlya, without furnishing sufficient proof in support of his contention. Of great importance is the identification among the Kolyma spirifers of a subgenus *Spiriferella*, i. e. *Sp. saranae* var. *wimani* Grab. and *Sp. keilhavii* v. *parryana* Toula. They are represented by well preserved specimens, and whether one believes the specific determination of this group, which is no easy matter for the taxonomist, to be accurate or not, the actual occurrence of its representatives in the Kolyma river basin makes further discussion and questioning of the Permian age of this fauna entirely superfluous. On the contrary, in the light of these data one may safely claim that the material described by M. Yanishewsky himself contained alongside of truly Lower Carboniferous forms typically Permian fauna as well.

A number of the samples we have been working at proved to be crowded with fragments of the prismatic layer of pelecypod shells. There were delivered also fairly well preserved specimens of these forms, described some time ago by B. Licharew after fragmentary specimens, like *Aphanaia*? sp. At the present time we deem it necessary to give them a new generic name—*Kolymia*, whose diagnosis may be formulated as follows:

Kolymia Licharew, g. n.

Shell irregular, more or less equivalved, inequilateral, narrowed in the anterior part and expanded posteriorly. Beaks pointed, nearly tangent. Hinge commissure straight or feebly concave. Anterior commissure short, rounded. Sculpture consisting of irregular concentric markings, wrinkles or ridges. Impression of posterior adductor rounded in outline, situated about in the middle of the hinge-line, not far from the commissure. Prismatic layer very strongly developed.

Genoholotype: *Kolymia inoceramiformis* Licharew, sp. n. (=*Aphanaia*? sp. ind., see Licharew, 1934, p. 76, pl. X, figs. 9 and 13, non 7, 10).

Besides the genoholotype, one more species of this genus—*K. irregularis* Lich., sp. n.—has been described, with a narrower configuration and with the youthful part of the shell separated from the remaining part of the shell by a sharp concentric constriction.

In 1934 B. Licharew when describing the Kolyma Permian fauna was inclined to refer it to basal parts of the Permian system; he approached it namely to the fauna of the Kashmir agglomerates and Euridesma beds of the Salt range, which by some (mostly English) geologists was believed to be even Upper Carboniferous. At the present time the question of accurate determination of the age of the Kolyma fauna seems to us to be more difficult. Unfortunately, a standard section of the entire Permian system characterized by fauna of the Kolyma type within the confines of Eurasia is still wanting. To judge about the fauna of the Upper Permian we are bound to use our Zechstein as a basis, however, the development of its fauna has proceeded under entirely specific conditions of an epicontinental nearly closed basin. The presence of vast numbers of representatives of the subgenus *Licharewia* and large *Productus cancrini* Vern. brings the Kolymian fauna nearer the Zechstein one, but it stands to reason that these forms had already occurred in the Lower Permian of the Scandic (this being partly supported by the evidence of the Lower Permian fauna of Novaya Zemlya), whence they migrated during the Upper Permian time to the Kazan sea.

Further finds of marine fauna and flora on the territory of Northern Siberia, as well as a more accurate description of sections of the Permian and of the contact of the latter with the Triassic in this region, will probably furnish a clue to the solution of this question.

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REFERENCES

[1] М. В. Куликов, Сб. научн. раб. комсом.-биол. АН СССР (1940) [2] Б. К. Лихарев, Тр. СОПС, сер. Якутск., вып. 14, Колымск. геол. экспед. 1929—1930 гг., I, ч. 2 (1934). [3] М. Янишевский, Мат. по изуч. Колымск.-Индиг. края, сер. 2, вып. 11 (1938).

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STRATIGRAPHY

ON THE UPPER CARBONIFEROUS GASTROPODS OF FERGHANA

By B. LICHAREW

(Communicated by P. I. Stepanov, Member of the Academy, 16.I.1941)

Gastropods are known to occur comparatively rarely in the Upper Carboniferous of Eurasia and seem to be there neither well preserved nor varied. This is true for Europe, but with the exception of the Upper Carboniferous of the Donetz basin, whereas in the Asiatic part of the USSR a fairly well preserved and rich gastropod fauna is contained in the Upper Carboniferous of Ferghana. An excellent collection was made therefrom at the beginning of the twentieth century by V. N. Veber. Later on it was considerably replenished by collections of I. S. Komyshan, O. I. Sergunkova and the author of this communication. The late A. V. Netchajew had undertaken a short time before his death a study of the collections then available; he succeeded but in describing representatives of *Bellerophontacea* and to identify 19 species from among them which he referred to the genera *Bellerophon*, *Bucania* (in fact *Bucaniopsis*) and *Euphemus* (=*Euphemites*), however, this part of Netchajew work was not completed either. Determinations made by him were used, among others, in the description of the geological map of the Isfarin sheet of Middle Asia, drawn by V. N. Veber. Having lain without use over 20 years after the death of its author, this manuscript became obsolete to a great extent. In 1939 I revised it on the basis of all the material that had accumulated up till then*. As a result of this work I was able to increase the number of Ferghanian *Bellerophontacea* more than one and a half times. In 1940 I had an opportunity to devote some time to a monographic study of other subfamilies. There are many gaps to be filled to bring the study of the fauna up to date (in particular, all of the *Neritidae*, *Subulitidae*, a considerable part of *Loxonematidae* are still to be treated). Nevertheless, up to the present time a total of 80 forms have been determined; most of them are new species. There is no reason, however, to regard the Ferghana gastropods as an endemic fauna, since similar faunas of this age from other regions have been studied very little, if at all. The fauna of the Carboniferous of Northern China, described by Yin (²), is known to be one of the few exceptions of this kind, however, it is by far poorer than the Ferghanian one (no more than 36 forms have been described). They include 6 species which have been found at present to occur likewise in Ferghana,

* We had to discard certain names given by A. V. Netchajew, since they proved to be preoccupied.

i. e. *Bucaniopsis calamitoides* Grab., *Pharkidonotus acuticarinatus* (Yin), *Euphemites annuliferous* Rom. (=*E. wongi* Grab.), *Pleurotomaris altispiralis* Grab., *Ptychomphalina tieni* (Yin), *Murchisonia (Hypergonia) quinquecostata* Yin. Besides, close to the Ferghana forms stand the Chinese *Solenospira? cochleoides* Yin and *Phymatifer fragilis* Yin. The majority of the enumerated forms are described from the Upper Carboniferous of North China, but some, like e. g. *Pharkidonotus acuticarinatus*, are known here but from the Middle Carboniferous. This circumstance is particularly noteworthy because of the aforementioned form being undoubtedly one of the most specialized ones. Still another specialized species is known to have as wide a vertical range as this one, namely *Bucaniopsis calamitoides*, which occurs in the Donetz basin already from the Middle Carboniferous (series K).

Resemblance to the gastropod fauna from the Donetz basin will evidently prove much less significant than one would have anticipated. This fact is particularly interesting in view of the considerable affinity between the Ferghanian fauna and that of the North American Pennsylvanian. While in most of the cases I was chary not to identify directly the Ferghana forms with the North American species, many of them are still very closely related to one another and should be regarded as varieties only. Such is e. g. the one described by me as *Euphemites carbonarius* Cox var.; *Microdorma gracile* sp. n. is very close to *M. conica* Meek et Worth.; *Ptychomphalina venustiformis* sp. n. belongs in the group of *Pt. millegranosa* (Girty) from the North American Pennsylvanian. *Goniasma isfaraensis* sp. n., very closely related to *G. lasallensis* (Worth.) is ranging very widely in Ferghana. In the Upper Carboniferous of Ferghana occurs also *Zygopleura (Pseudozygopleura?) pupa* Knight.

On considering the vertical range of the established forms, we observe that the horizon showing the most luxuriant development of the gastropod fauna is the Pseudoschwagerina one (Kara-chatyr range) which has yielded up to 46 species. In the successive horizon (designated by the author as C_3^f) underlying the last-mentioned one the number is reduced to 7. Practically all of these forms occur higher up as well. Beds with *Isogramma paotechowensis* and sponges on the Isfara river have yielded 17 species, half of them occurring in the Pseudoschwagerina limestone of Kara-chatyr; the rest are new species. Exact correlation of these beds with the Kara-chatyr section will probably be possible only upon a comparative study of the microfauna abounding in the limestones of these two regions.

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REFERENCES

[1] В. В е б е р, Геолог. карта Ср. Азии, лист VII-6 (Исфара), сев. половина, Тр. Всесоюзн. геол.-разв. объед., вып. 194 (1934). [2] T. Y i n, Palaeont. Sinica, ser. B, XI, fas. 2 (1932).

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GENETICS

ADDITIONAL DATA CONCERNING THE MATING SYSTEM IN WILD POPULATIONS OF COMMON HAMSTER *(CRICETUS CRICETUS* L.*)*

By S. GERSHENSON

(Communicated by I. I. Schmalhausen, Member of the Academy, 1.II.1941)

As shown in our recent papers devoted to the analysis of a dimorphic wild population of the hamster from the Malo-Devitsa region of the Ukrainian SSR ([1], [2]), melanism is inherited in the hamster as a simple autosomal dominant, and mating in the population studied occurs at random, i. e. the distribution of genotypes coincides very closely with the requirements of Hardy-Pearson's formula $(p^2AA + 2pqAa + q^2aa)$. In addition to our data, some light is thrown on the problem by the materials published by Kryshtal ([3]). In the summer 1928 this investigator collected in the neighbourhood of the Chartoryi Agricultural Station (Ukrainian SSR) 112 hamsters, 83 of which were brown and 29 black ones. Hence we can conclude that the concentration of the gene for black colour (A) in this population was equal to 0.14, while the concentration of the gene for brown colour was equal to 0.86. As in our case, most of these hamsters have been obtained as whole litters, each of which consisted of the mother with all her young. In all, 10 such litters have been collected, in 7 of which the mothers were brown and in 3 black.

Repeating the argumentation developed in our work on the Malo-Devitsa population, we can calculate on the basis of the hypothesis of random mating the types of offspring expected from both kinds of females, and then compare the expected results with those actually obtained.

As brown is recessive, the ratio of brown and black individuals in the offspring of brown mothers should correspond to the ratio of q and p in the population. Table 1 shows the theoretically expected and actually obtained numbers of both types of offspring in the progeny of brown mothers collected by Kryshtal.

Table 1

	Brown	Black	Total	% of black
Theoretically expected	49.9	8.1	58	14.0 ± 4.6
Actually obtained . .	50	8	58	13.8 ± 4.5
Difference	0.1	0.1	—	0.2 ± 6.4

Among the three black mothers obtained by Kryshtal we can use for our purpose only two which were certainly heterozygous, i. e. those which gave in their offspring both black and brown individuals. The third black mother gave only three black individuals, and since its genotype remains therefore uncertain (*AA* or *Aa*), we must exclude it from our calculations. The results theoretically expected and the actually obtained numbers in the progeny of the two heterozygous black females are shown in Table 2.

Table 2

	Brown	Black	Total	% of black
Theoretically expected	7.7	11.3	18	62.8 ± 11.4
Actually obtained .	5	13	18	72.2 ± 10.6
Difference	2.7	2.7	—	9.4 ± 15.5

As can be seen from Tables 1 and 2, the data actually obtained by Kryshtal are in fair agreement with the expectations based on Hardy-Pearson's formula. Notwithstanding the small numbers of individuals obtained from the Chartoryi population, we can evidently conclude that here mating also occurs at random.

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REFERENCES

[1] S. Gershenson and V. V. Polevoj, C. R. Acad. Sci. URSS, XXIX, No. 8/9 (1940). [2] S. Gershenson and V. V. Polevoj, ibid., XXX, No. 1 (1941). [3] О. Кришталь, Вісник природознавства, 1—2 (1929).

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GENETICS

ON THE INFLUENCE PRODUCED BY THE PREVIOUS HISTORY OF THE SPECIES ON ITS SUBSEQUENT EVOLUTION

By J. M. OLENOV

(Communicated by I. I. Schmalhausen, Member of the Academy, 30.XI.1940)

The possibilities of further development of a species, genus, or larger systematic group are always to a certain extent determined by their previous history. Sometimes the possibilities are greatly restricted, as e. g. in forms that have entered the path of degeneration, or in highly specialized groups ([1]), both fossil and recent. But even in cases when historically determined peculiarities of the organization produce no such distinct restrictions of the possibilities of further evolution, it is by far not every change that may actually be realized; and not all the possible variations are realized with the same facility.

It is impossible to obtain a deeper insight into the problem of orthogenesis in the evolutionary process without having a clear idea of the nature of the influence produced by the previous history of a given taxonomic group on the group's subsequent development. It is known, that the antidarwinians have made their best to take advantage of the data referring to this problem; one of the aims of the modern darwinism is to prove the efficiency of the theory of natural selection as accounting for the phenomena of orthogenetic evolution. No attempts have so far been made to analyze the causes that restrict evolution with regard to those small taxonomic groups, the development of which is within the reach of experimental investigation. If such an analysis were carried out, we would be justified, on the basis of Darwin's theory of divergence, to apply the conclusions thus obtained to the discussion of the way of macroevolution.

As has recently been shown by Schmalhausen ([2]), the recapitulation phenomena are the result of a complex system of correlation which makes impossible any marked shift or ruptures, without affecting the viability of the developing individuum. We believe that a similar answer is to be given to the question advanced by us, namely that the restrictive influence upon the course of the further evolution is due to correlations formed in the previous history of the species*.

The authors Timofeef-Ressovsky ([12]) and Balkashina and Romashov ([13]) as well have drawn attention to the fact that some of the cases of parallel variability in the species of the *Drosophila* genus (phenotypically similar mutations in various species) are likely to be due in different species to genetically different causes. Most important is the fact emphasized by Bal-

* The restrictive influence of the species' previous history upon its subsequent development cannot be accounted for by the conservatism of hereditary structure which had been often overestimated [([3]—[10]). comp. ([11])].

kashina and Romashov ([14]) of high frequency of the changes occurring in populations of wild *D. phalerata*, *D. transversa*, *D. vibrissina*, *D. funebris*, interpreted by the authors as instances of phenotypical parallelism*.

The parallelism of mass changes in many species of the *Drosophila* genus cannot be explained by a similar trend in selection, since in most strains that show these changes the viability is strongly (sometimes very sharply) reduced ([3]). Thus, if it could be proved that these changes are in different cases due to different genetical causative agencies, we would be justified to formulate the following most important conclusion: the parallelism in the variation of connected species may be dependent not only on the closeness of the genotype of the species compared, or on an analogous trend of selection, but it likewise depends upon other causes which. must be analyzed. As may be seen from the above, we believe these to be the ontogenetic correlations formed in the course of the previous history of the group.

When the same variation occurs in different species and does not depend on mutations of some gene present in each of them, it is evident, that the historically formed sequence of the processes of ontogenetic development of a given species of the genus shows the same vulnerable points, which means that many species of a given genus possess in their ontogeny the same feeble points. But in this case the mass changes characteristic of many species must be due to different genetic causes not only in different species, but within one and the same species, too, and even within a population.

While studying the dynamic of the genic composition of wild *D. melanogaster* populations, we have found that the mass changes observed in this species (phenotypically coinciding with similar changes in other *Drosophila* species) are determined by different genetic causes that vary according to the strain within the same population ([3], [6], [22]). The following example may be cited. All the disturbances in venation of the wing (affecting the *crossvein posterior*) frequently observed by us in 1937 in the Uman population, have been classed by us into 4 groups. However, these groups are far from being clearly delimited: 1) *crossvein posterior* incomplete or absent; 2) *cv. post.* sends off one or several branches; 3) strains in which both above characters occur; 4) a supplementary, usually incomplete, third *crossvein* is present. The data referring to the 1 and 4 group are given in the table. These groups were chosen because the strains of which they are composed were of a recessive character, the results obtained being therefore more illustrative. As may be seen from the table, all the strains studied proved non-identical. We obtained analogous data for other populations and from our analyses of other mass changes occurring in a number of other species (such as divergent wings and emarginate wings of the *Beaded* type).

When comparing the above facts with other data concerning the genetics of wild populations of *Drosophila*, we find only the following interpretation to be satisfactory**: the diverse genetic causativeness (within one population)

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* Analogous changes were found in other species ([15–18]) including *D. melanogaster* ([18–21]).

** The following explanations do not hold: 1) disturbance of the hereditary balance in the case of crosses with individuals from a laboratory strain; 2) connexion between the phenogenetic action of some genes and their mutability [a rather peculiar idea recently suggested on a different occasion by Gershenson ([23])]; 3) plurality of genes apt to disturb the normal course of ontogenesis at its most vulnerable points; 4) presence in the natural chromosomes of mutant genes, such conditions being created under which even those mutations, that would have had no effect upon the phenotypic manifestation, now disturb the normal course of development where it is the most vulnerable. All these explanations are disproved by the following data: 1) detection of identical mass changes in the case the inbreeding method ([20], [23]) is applied, or else by means of a simple examination of flies from wild populations ([24]); 2) frequent occurrence of the same changes as

of changes, most frequently occurring in some species, is accounted for by continuous transformation of the normal genotype proper to wild populations ([3]).

1) Mutant genes, easily introduced into the normal genotype. If such is the case, the alterations in the genotype are effected without any changes in the phenotypes' stability, in other words, the determining connexions existing in ontogenesis remain the same, or else their changes do not reduce the security of the definitive characters. Into this category presumably belong most of the mutant genes participating in the process of transformation of the normal genotype. To detect them special methods are required.

2) Mutant genes which are difficult to introduce into the normal genotype: an alteration in the genotype takes place, but it is accompanied with a transient decrease in the stability of the phenotype. The changes that occur in this case in the determining connexions produce a temporary, compensatory decrease in the security of definitive characters, since in the historically

Identification of Several Strains from the Uman 1937 Population

(Number of Flies Studied in F_1 and their Phenotype)

$1_1 \times 1_2$	$1_1 \times 1_3$	$1_1 \times 1_4$	$1_2 \times 1_3$	$1_2 \times 1_4$	$1_3 \times 1_4$
349 +	590 +	532 +	614 +	461 +	503 +

$4_1 \times 4_2$	$4_1 \times 4_3$	$4_2 \times 4_3$
526 +	498 +	617 +

$1_1 \times 4_1$	$1_1 \times 4_2$	$1_1 \times 4_3$	$1_2 \times 4_1$	$1_2 \times 4_2$	$1_2 \times 4_3$	$1_3 \times 4_1$	$1_3 \times 4_2$	$1_3 \times 4_3$	$1_4 \times 4_1$	$1_4 \times 4_2$	$1_4 \times 4_3$
471 +	312 +	508 +	515 +	493 +	530 +	468 +	411 +	372 +	446 +	418 +	497 +

$1_1 + 1_1$	$1_2 \times 1_2$	$1_3 \times 1_3$	$1_4 \times 1_4$	$4_1 \times 4_1$	$4_2 \times 4_2$	$4_3 \times 4_3$
186 + ;	216 + ;	387 + ;	244 + ;	308 + ;	286 + ;	260 + ;
131 incompl. *cv. post.* 22 *cv. post.* absent	169 incompl. *cv. post.* 83 *cv. post.* absent	44 incompl. *cv. post*	195 incompl. *cv. post.* 16—3rd *cv.* (incompl.)	59—3d *cv.* (incompl.) 8 incompl. *cv. post.*	61—3rd *cv.* (incompl.)	49—3d *cv.* (incompl.) 38 incompl. *cv. post.*

(continued)

a part of the pleiotropic effect of the mutations characterized by other phenotypica peculiarities ([3, 6, 12]): 3) relatively low frequency of these changes in old laboratory strains as compared to newly taken from nature; and 4) by the results of a study of the mutational process in wild II chromosomes which, according to previous analysis, contain no mutant genes (thus e. g., out of the 17 strains of the 1938 Bobrov population, the number of chromosomes studied amounting to 435, the changes involving the *cv. post.* appeared among the progeny of one or several males out of 9 strains, «divergent» have been noted in 6 strains and changes of the *Beaded* type in 3 strains).

conditioned sequence of the processes of ontogenetic development highly vulnerable points are involved. This is expressed in a plurality of modificators activating the manifestation of mutant genes on their introduction into the normal genotype, and in the mass character and non identity of the changes due to such an activation. The phenomena of a phenotypical parallelism of non-identical, even within the limits of one population, mass changes, find their explanation in that the species compared possess identical vulnerable points in their ontogenesis.

By investigating mass non-identical changes that repeat themselves in a number of species, we obtain a knowledge solely of the stabilizing activity of selection, for the transformation of the normal genotype is in this case accompanied with no change in the normal phenotype. This analysis, however, permits to foresee distinctly different results in the action of a natural selection, too.

3) Mutant genes, upon the introduction of which into the normal genotype an alteration in the genotype is only possible at the expense of an irreversible decrease in the phenotype's stability, or else at the expense of changes in the phenotype. The changes occurring in such cases in the determining connexions produce either a non-compensated decrease in the security of definitive characters which finally brings out changes in them, or an obligatory change sets in immediately.

We have here one of the ways of the origination of new geographical races, one of the forms of the manysided race producing activity of selection. In this case, owing to the identity of the most vulnerable points in the ontogenetic system of correlations in related species, a parallelism in the race production in these species must presumably exist, a distinct similarity in the characters in the geographical races belonging to these closely connected species and highly differing in their habitat. Most illustrative examples of this sort of parallelisms may be found in Rensch's paper ([25]). Their correct interpretation is of great interest for, although the orthogenetic changes in some of the morphological characters depend here not upon the trend of selection, but upon the identity in closely connected species of the most vulnerable points in the ontogenetic system of correlations, it is still selection that is the cause of the speciation process.

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REFERENCES

[1] А. И. Северцов, Главные направления биолог. прогресса (1925). [2] И. И. Шмальгаузен, Организм как целое в инд. и ист. развитии (1938). [3] J. M. Olenov and J. S. Kharmatz, C. R. Acad. Sci. URSS, XXIV, No. 5 (1939). [4] N. J. Muller, Biol. Rev., XIV, 3 (1939). [5] M. Demerec, Genetics, XXII, No. 5 (1937). [6] J. M. Olenov and J. S. Kharmatz, C. R. Acad. Sci. URSS, XIX, No. 5 (1939). [7] G. G. Tiniakov, ibid., XXII, No. 9 (1939). [8] J. M. Olenov, J. S. Kharmatz, etc., ibid., XXIV, No. 5 (1939). [9] M. G. Tumanian, ibid., XVI, No. 6 (1937). [10] H. S. Eister, Genetics, XXIII, No. 1 (1938). [11] N. W. Timofeef-Ressovsky, Exper. Mutationsforschung in der Vererbungslehre (1937). [12] H. A. und N. W. Timofeef-Ressovsky, Arch. Entw. Mech., CVIII, I (1926). [13] С. Д. Ромашов и Е. И. Балкашина, Журн. эксп. биол., V (1929); VI (1930). [14] Е. И. Балкашина и Д. Д. Ромашов, Биол. журн., IV, 1 (1935). [15] Metz et al., Publ. Carneg. Inst., No. 328 (1923).

[16] W. P. Spencer, Genetics, XIII (1928). [17] S. Gershenson, Am. Nat., VIII (1934). [18] C. Gordon, J. Genet., XXXIII (1936). [19] С. С. Четвериков, Тр. III съезда зоол., анат. и гист. (1928). [20] H. A. und N. W. Timofeef-Ressovsky, Arch. Entw. Mech., CIX, 1 (1927). [21] Н. П. Дубинин и др., Биол. журн., III, 1 (1934); V, 3 (1936). [22] S. Gershenson, C. R. Acad. Sci. URSS, XXVI, No. 6 (1940). [23] C. Gordon et al., J. Genet., XXXVIII, 1—2 (1939). [24] Н. П. Дубинин и др., VI, № 2 (1937). [25] B. Rensch, Biol. Rev., XIV, 2 (1939).

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PLANT PHYSIOLOGY

ELIMINATION OF LEAVES IN GRAFTING

By B. S. MOSHKOV

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It has been established by the author that in order for one branch of a short-day plant to impart its photoperiodic response to another branch it is necessary: 1) that on the short-day treated branch all its growing points should be removed, and 2) that all leaves should be removed on the branch treated with continuous light. The removal of leaves is either a surgical operation, i. e. the leaves are severed from the branch, or else they are left on it and eliminated physiologically while being kept in the dark. In the case of crysanthemum buds appear on the continuous daylength branch under the influence of the leaves of the short-day branch when the former is stripped of its own leaves altogether, or when it only bears them screened from the light. From these tests I proceed to new ones in order to find out how a scion deprived of leaves would be influenced by the leaves of the stock. I tried also to use this method in citrus plant graftings with the aim to hasten the development of seedlings and to induce economically valuable changes in their biochemistry. This, however, was a disappointing experiment. The scion seedlings (orange and Duncan) would not grow without leaves and even died away gradually. But they did make growth, and a very good one, when their leaves were no longer cut off. Naturally enough, there arises the question as to the reason that caused the seedling to cease growth after the removal of leaves. This may be merely a consequence of the injury occasioned by the operation, or perhaps they can make no growth at all at the expense of alien (stock's) leaves and require a minimum number of their own. To clear up this point, a new experiment was started in the summer 1940. This time two species of perilla (a short-day annual) were involved.

The object was to bring about a rapid and profuse flowering in the seedlings of the red perilla (*P. nankiensis*) used as scion under the influence of the leaves of the white perilla (*P. ocimoides*) used as stock. The scions were given continuous illumination throughout the experiment, but the stocks were only started on continuous daylength in order to secure a sufficient number of well formed leaves. As soon as there were 4 or 5 pairs of leaves on them, they were transferred to a 10-hour daylength and kept on it until grafting. After a fortnight of treatment with short photoperiods the red variety seedlings were grafted upon the white variety. Curtailing the daylength was continued by placing the stock plants singly under pasteboard cylinders. All their growing points had been cut out. The scions remained on continuous daylength. There were five different sets in the experiment, each including six units.

Set 1. The scions had all their leaves intact. This was to try once again whether these leaves would interfere with the influence of the stock's leaves on the development of the scion.

Set 2. The scions with their growing points were directly under the influence of stock's leaves, while their own leaves were severed from them as soon as they were at the end of growth.

Set 3. Only the lower leaves which had already reached their normal size were severed from the scions. Practically the latter were always bearing only two or three upper pairs of leaves.

Fig. *1*. Red perilla (scion), from left to right. A plant from set 1 (all leaves intact). Fig. *2*. A plant from set 5 (the whole scion in darkness). Fig. *3*. A plant from set 2 (all leaves severed).

Set 4. The scion's leaves were shut in the dark as soon as they had expanded.

Set 5. The whole scion developed in the dark so that not only its leaves, but its stem and reproductive organs as well were guarded from the influence of the light.

In set 1, 5 grafts had survived the test, but 2 of them bore no buds and on the remaining 3 the buds had formed as late as 50—60 days after grafting. And although it is usual with bud formation on short daylengths that flowering involves the top first and proceeds down the stem, here the case was reverse and the formation of buds had been in the upward direction. This betrays the influence of the stock and shows that some substances had been moving from it to the scion.

In set 2 the scions robbed of their leaves formed no buds at all and their growth was checked strongly. Both elongation and branching were 4 or 5 times less in these scions than in those of set 1 (Figs. *1* and *3*).

Severing the lower leaves in set 3 failed to inhibit the growth of scions and did not interfere with the formation of buds. The buds appeared August 20, i. e. on the 28th day after grafting.

Screening of the developed leaves in set 4 had a depressive influence on the growth of the scions, but the inhibition of growth was not so strong as in set 2. The buds appeared August 17, on the 25th day after grafting.

Keeping in darkness of the whole scions in set 5 resulted in their considerable etiolation, but neither flowering nor fruiting were delayed. The buds had appeared August 13, on the 21st day after grafting (Fig. *2*). This is the usual term for budding in perilla plants grown on short daylengths.

The evidence furnished by these tests is that the delay in development caused by severing the upper leaves is connected largely with the mechanical injury occasioned by the operation rather than with any specific rôle of these leaves in the synthesis. But it is also possible that the leaves adjoining the growing zone are transmitters and indispensable links in some complicated process.

In practical grafting, when the object is to influence the development of one of the components by the leaves of the other, the best thing is to put the former in darkness either entirely or excepting the top, if the variety concerned will not tolerate darkness. I tried this method in my experiments with chrysanthemum in 1935.

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PFLANZENPHYSIOLOGIE

ZUR FRAGE DES CHEMISMUS DER PHOTOSYNTHESE

Von N. N. OWTSCHINNIKOW

(Vorgelegt von A. A. Richter, Mitglied der Akademie, den 2.II.1941)

Die Theorien der Photosynthese von Willstätter und Maquenne setzen im Photosyntheseprozess die Bildung der Hyperoxydform $-O-CH\begin{matrix}O\\|\\O\end{matrix}$ voraus, die dann unter der Wirkung der Katalase O_2 abspaltet ([1], [2]). Ist dies der Fall, so ist man berechtigt anzunehmen, dass die bei der Photosynthese O_2 aus dem Hyperoxyd $-O-CH\begin{matrix}O\\|\\O\end{matrix}$ ausscheidende Katalase und die bei der Atmung H_2O_2 unter Ausscheidung von molekularem Sauerstoff zersetzende qualitativ verschieden sein können. Es wird in der Tat O_2 im ersten und im zweiten Fall aus Stoffen verschiedener Stabilität isoliert, und die Katalase der Photosynthese muss somit eine grössere Wirkungseffektivität besitzen, als dies für die Katalase der Atmung erforderlich ist.

Um zu prüfen, ob die Katalase der Photosynthese mit der der Atmung identisch ist, oder ob diese beiden Katalasen sich qualitativ voneinander unterscheiden, habe ich, sowohl für die eine, als auch für die andere, deren Fähigkeit, die Aktivierungsenergie herabzusetzen, experimentell ermittelt, da diese Fähigkeit die das Ferment charakterisierende Haupteigenschaft ist ([3], [4]). Zu den Versuchen wurden 7-tägige Weizenkeimlinge der Sorte «Ukrainka» verwendet, wobei ein Teil der Keimlinge im Licht, der andere im Dunkeln wuchs, in den einen kamen die Photosynthese und die Atmungsprozesse zustande, in den anderen nur die Atmungsprozesse. Die Aktivierungsenergie wurde nach der Formel von Svante-Arrhenius ([5]) bestimmt, wozu man vorläufig die Geschwindigkeitskonstanten (K) der Zersetzung von H_2O_2 unter dem Einfluss der Katalase bei verschiedenen Temperaturen ermittelte. Die Bestimmung der Konstanten der Reaktionsgeschwindigkeit geschah für die Extrakte, die folgendermassen hergestellt wurden. Eine Blättereinwage von 1500 mg wurde mit 30 cm³ Phosphat-Pufferlösung (pH = 6.9 8) verrieben und dann zentrifugiert. Der nach dem Zentrifugieren erhaltenen klaren Lösung gab man 90 cm³ destillierten Wassers zu. Die Konstanten der Reaktionsgeschwindigkeit wurden manometrisch mit sechsmaliger Wiederholung bestimmt. Die Gesamtergebnisse der Versuche bringt nachgehende Tabelle.

Versuchsobjekte	Katalasenextrakt	Aktivierungsenergie A
Etiolierte Blätter	Atmungskatalase	5679
Grüne Blätter	Atmungskatalase und Photosynthesekatalase	1047

Wie die gewonnenen Ergebnisse zeigen, ist die Katalase in etiolierten Blättern weniger effektiv, als die Katalase in grünen Blättern. Das besagt, dass die Katalase der Photosynthese der Katalase der Atmung nicht identisch ist. Diese zwei Katalasen unterscheiden sich untereinander, wenigstens in der für die Fermente wesentlichsten Eigenschaft—in der Fähigkeit die Aktivierungsenergie herabzusetzen.

Es wird andererseits durch die effektivere Katalase im Photosyntheseprozess und durch die weniger effektive im Atmungsprozess Willstäters und Maquennes Voraussetzung des Vorhandenseins der Superoxydform—O—CH$\begin{matrix}O\\|\\O\end{matrix}$ bei der Photosynthese indirekt bestätigt.

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ZITIERTE LITERATUR

[1] Д. И. Сапожников, Сов. ботаника № 6—7 (1939). [2] В. Любименко, Фотосинтеза і хемосинтеза, нагромадження энергии рослиною, Д. С. Г. В. (1933). [3] Проф. Благовещенский, Природа, № 2 (1938). [4] Н. Н. Овчинников, Яровизация, № 2 (1940). [5] К. Оппенгеймер и Р. Кун, Ферменты (1932).

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AGROPHYSIOLOGY

NEW METHODS FOR BREAKING DORMANCY IN RECENTLY HARVESTED POTATO TUBERS

By T. S. TER-SAAKIAN

(Communicated by A. A. Richter, Member of the Academy, 1.II.1941)

Summer planting has been suggested by T. D. Lyssenko ([3]) as a method for controlling the degeneration of potatoes in the South. But storage of potato tubers for seed at that time is often a very difficult problem under conditions of a hot climate.

Since 1933 I have been studying the question of obtaining two yields of potato per year. In connexion with this I had to search for the ways of bringing to germination the freshly harvested tubers to be planted in summer in hot regions. Not until 1938, however, did I come to definite results, which then made the basis for further experiments carried out in 1939—1940.

Workers in many different countries have used various methods in their attempts to induce germination in potato tubers soon after harvest. The warm bath of Molish was tried as well as keeping the tubers at 0° C ([12], [13]) or drying them ([7]); the tubers were also peeled or cut up, or their eyes were pricked ([11]), or else they were treated with fuming substances, such as tobacco or sulphuric ether ([4]); sometimes peeling was followed by keeping the tubers in a moist sand ([1]); and to end with, their treatment with ethylene chlorhydrin and potassium thiocyanate was attempted ([9], [10], [2], [6], [5]). None of those methods, however, has solved the problem of mass germination on a commercial scale.

While carrying on a number of tests with different varieties of potato in various parts of Armenia, I observed more than once sprouting of unripe and even not yet fully formed tubers on the parent plant in the second half of July, when the temperature continued as high as 25—30° C and the soil contained sufficient quantities of moisture. Such tubers send out green sprouts which turned into stalks, came to flower and formed new young tubers. If severed from the parent plant and set away in the ground, they developed normally, too, though at a slower rate. Perfectly sound and large tubers can be produced in that way.

It is on that observation that I based my experiments in which tubers from spring plantations were induced to sprouting. In nature I had found young tubers to sprout at 25—30° C, when there was enough moisture in the soil and the tubers were lying at some depth below the surface, where they were not easily reached by the air.

Now my aim was to reproduce these conditions in the experiment. I started it on an experimental plot at this Institute. The varieties involved were

Epicure, Early Rose, Lorch, Narodny, Phytophtora resistant 8670 and Voltman. Among the various methods of keeping tried then, the most effective was when the tubers were kept in trenches. A pit 1 m wide, 15 to 20 cm deep is dug on an open and flat spot. Its length is a matter as we will it, but 2 to 3 m, according to the bulk of available seed material, seems to be the most appropriate range. Before pouring the tubers in, the trench is moistened with water, but not to the limit of the water holding capacity of the soil. The selected young tubers must be ripe and good-sized, ranging in weight between 40 and 60 g. After the pit is brimful with potatoes, it is covered first with a layer of straw 3 cm thick and then with a layer of earth, whose thickness is not over 10 or 12 cm. The earth is rammed and watered from a watering-pot, but the water must not reach the potatoes. Instead of watering and ramming one can put on top a thin (1—2 cm) layer of strongly moist soil.

In a trench of that kind the temperature in July will be 25—30° C, and while the penetration of air is limited moisture is sufficient. Under these conditions the tubers show sprouts on the 12—15th day. The ratio of sprouted tubers at that time is 80—90% for the late (Volman) as well as medium late varieties (Lorch, Narodny, Phytophtora resistant 8670) and is only 1—2% for the early varieties (Epicure, Early Rose). This relation between the germination ratio and earliness was observed in all the tests carried out within a space of 3 years (1938—1940).

The tubers thus sprouted must not be planted into a dry soil, or the sprouts will make poor growth and most of them will perish; a moist soil is required here for planting. Each of the recently harvested tubers when sprouted and put in the soil in summer, will send forth a vigorous stem with a large leaf area. And to have a single stem from a tuber is of advantage not only in summer planting. I have found that removal of superfluous stems in potatoes planted in the spring also tends, especially in hot years, to increase the leaf area and thereby the yield.

Summer planting in 1938 and 1939 of unsprouted tubers resulted in a very slow and irregular germination which did not exceed 30—35%. And when the season between frosts came to an end, the plants had not yet come to a condition of full development, and had formed only a few small tubers.

The data brought together in the annexed table relate to an experiment of 1940. It was run with tubers harvested from a spring plantation. The varieties involved were Lorch, 8670 and Narodny. Part of the tubers were planted on July 10 and served for control. The rest was sprouted at first, and set in the soil only on July 25. These produced plants which greatly excelled the controls both in growth and development, as is obvious from the table, where yield data (harvest, November 23) are also given.

Yield and Development of Potatoes as Affected by Sprouting the Seed (1940)

Variety	Set	Planted area (25×60 cm² room for each plant)	Number of tubers planted	Number of plants grown up	Weight of tubers per plant in g	Total weight of harvested tubers in kg
Lorch	Sprouted . . .	9 m²	50	47	240	11.28
»	Unsprouted . .	9 »	50	26	160	4.16
Narodny	Sprouted . . .	9 »	50	37	125	4.62
»	Unsprouted . .	9 »	50	18	70	1.26
8670	Sprouted . . .	9 »	50	43	180	7.74
8670	Unsprouted . .	9 »	50	26	95	2.47

As will be apparent from the table, it is only by breaking dormancy that a second crop of potatoes can be obtained in the same year. In the tests reported the physiology of the tubers was not studied while breaking their dormancy, but the conditions created by the treatment seem to be very similar to those set up by other investigators in their experiments. Indeed, it is on account of oxygen deficiency and increased temperature that the period of rest is broken in plants when they are treated with a warm bath according to Molish ([8]). Another method suggested for breaking dormancy consists in keeping the plants in an oxygen free medium ([14]).

In 1939 on the experimental plot of this Institute a second planting of potatoes harvested a short while before was done on August 16. The same method was used in breaking the dormancy of harvested tubers, but the area planted was now 0.7 ha. In November the second crop was lifted, 80 centners per hectar. These tubers were sound and large. We were then encouraged to further experimental work by this method by a special committee under the People's Commissariat for Agriculture of the Armenian SSR. So second planting of potatoes was tried again in the cotton-growing districts of Armenia in July—August 1940; this time the area planted was 93 hectars. In a number of places where unsprouted and uncared-for tubers were planted in July, the crop appeared above ground too late and was sparse: the yield was poor or lacking at all. On the other hand, as high yields as 6 to 9 tons per hectar were lifted by the collective farm workers in two districts (Kamarlin and Zangibassar), where the tubers had been sprouted, according to the described procedure, previous to planting.

Second yield of tubers (235 kg) obtained from one plant of variety Lorch after summer planting. On the right hand in the figure are berries which gave fully mature seed; in the lower part of the plant the parent tuber from the spring planted crop is seen.

These results will lead to the conclusion that in regions with a long period between frosts two high yields of potatoes can be obtained in a year, if the harvested tubers are sprouted before the second planting, according to the method described in this paper.

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Received
2.II.1941.

REFERENCES

[1] А. М. Бурачинский, Яровизация, № 2, 94 (1938). [2] Т. А. Красносельская-Максимова, П. В. Сабурова и К. Л. Маттисен, Соц. раст., сер. А, № 11 (1934). [3] Т. Д. Лысенко, Борьба с вырождением картофеля на юге УССР (1936). [4] Т. Д. Лысенко, Проращивание молодого картофеля (1935). [5] Ф. А. Новиков и Д. А. Мозолькова, Овощеводство, № 5, 39 (1939). [6] Л. В. Рожалин, там же, № 5, 36 (1939). [7] Д. А. Сикстель, Соц. раст., № 11 (1934). [8] K. Boresch, Biochem. ZS., I, 313 (1924); II, 466 (1926); III, 180 (1928). [9] F. E. Denny, Am. Jrnl. of Botany, XII, 386 (1926). [10] F. E. Denny, Contrib. Boyce Thompson Inst., 9, 238 (1938). [11] Koltermann, Newton, Appleman, Schlumberg and Schmidt, quoted after Miller et al., Зап. Пушк. с.-х. ин-та, VIII (1938). [12] Müller-Turgau, Ldw. Jahrb., II, 751 (1882). [13] Müller-Turgau, Flora, Neue Folge (1910). [14] F. Weber usw., Sitzber. d. Kais. Akad. d. Wiss. in Wien, Abt. I, CXX, 179 (1911).

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PLANT ANATOMY

SHIFTING OF THE TORI CONNECTED WITH AGEING

By L. I. DJAPARIDZE

(Communicated by A. A. Richter, Member of the Academy, 2.II.1941)

1. It is the general opinion that the membrane of the bordered pits in conifers with its thickened torus acts like a valve regulating the flow of water from one tracheid into another ([3], [14], [17], [26]). But there are some indications which deny such an action of the membrane and the torus ([3], [18], [23]), thus leaving the question of the closing action of the torus unsettled and in need of special investigation. The existing several works on this subject deal chiefly with dry wood as material to be soaked by preserving substances ([18], [21], [22], [24—26]). These investigations have definitely established that the pifficulty of artificial impregnation of dry wood is due to the shifting of the tori which close the pit aperture preventing the penetration of the fluid. It has been shown that the shifting of the tori takes place in the course of the wood drying process ([21], [25]), and a hypothesis has been proposed in order to explain the mechanism of the closing of pits as a result of the dehydration of the wood ([25]).

2. Whether or not the shifting of the tori occurs in normally growing trees has not been established beyond doubt. Phillips ([25]) has observed closed pits in recently felled wood still containing a considerable amount of free water. Jeffrey ([23]) states that during the formation of heartwood, all the tori are shifted into a position in which they close the pit aperture. Scarth and Spier ([27]) suppose that this shifting occurs as the result of the secretion of pitch and other viscous substances which takes place when cells are dying off.

All at the same time it is known that in different sections of the wood the water conductivity is very different. This is true of deciduous trees ([1], [2], [16]) as well as of conifers ([9]). The difference is brought out by comparing the water conductivity of annual layers of wood of different age. The rupture of connexions with the transpiring organs and the root system is not alone responsible for it. Isolated sections of the tissue extracted from the living tree ([9]) also show varying degrees of water conductivity, and so here is likely to be concealed the cause that directly accounts for the variation ([9], [11]).

3. Considering that the permeability of a dry wood depends upon the condition of the pits, it is natural to suppose a similar relation between the position of the tori and the water conductivity in a living tree. Our investigations on this subject gave positive results. It was observed that as the water conductivity in deep layers of the wood of *Picea orientalis* (L.) Link. and *Abies Nordmanniana* (Stev.) Spach. became lower, the number of closed pits grew higher ([11], [13]). Closed pits, i. e. such pits, the torus of which is shifted so strongly that it corks up the pit aperture, are already present in the growing tree. Investigation proves that the shifting of the tori in a growing tree is connected with the ageing of the wood.

4. The tracheids of conifers die out very soon after their emergence from the cambium and fulfil their function of water carriers when they are already dead. In time, these dead elements of the wood undergo definite changes; the state and the properties of their covers become different. The changes in the tracheid covers connected with age influence their adsorptive properties with regard to eosin; the absorption of iodine decreases with the ageing of the wood ([4]). It may be supposed that the hysteresis can be accompanied by the deformation of the pit membrane which is like a web in a suspended and strained position. The shifting of the tori must be considered as an effect of the deformation.

5. The shifting of the tori connected with ageing begins from the outset of development of the water conducting tissue. In time the process of the shifting of the tori from their central position to the closing one becomes more pronounced ([11, 13]). With the increase of the number of pits closed by the torus, the water conducting capacity of the wood decreases. Eventually the closing of pits stops the function of the tissue. Therefore, the water conductivity is not determined by the total number of pits in annual layer, but rather depends on the presence of active, i. e. open pits, through which aqueous solutions can be conveyed from one tracheid into another ([13]) (Table 1).

Table 1

Content of Pits in Early Wood

Age of wood	*Picea orientalis*							*Abies Nordmanniana*						
	1	10	30	50	60	80	100	1	10	30	50	60	70	80
Total number of pits per 1 mm²	171	258	239	153	230	391	362	457	387	498	375	304	289	150
Number of closed pits	2	3	23	15	220	358	331	4	12	23	196	138	135	90

Table 1 shows that in *Picea*, contrary to *Abies*, the total number of pits increases in the direction from the periphery of the wood towards the pith; but the inactive pits in both species equally increase in number towards the pith. And in both species this goes parallel with a decrease of water conductivity in the same direction ([9]). Dead wood is also decreasingly water conductive toward the pith ([5, 6, 9, 13]).

6. Deformation of the membrane and the shifting of the torus connected therewith proceed gradually, which is shown by the fact that between the central position of the torus and its ultimate closing position every possible kind of intermediate position is observed ([11, 13]). In this, the shiftings of the tori in the living wood differ from those which appear when wood is dried artificially. In dry wood only two positions of pits have been reported by several different investigators—the open and the closed one ([15, 22, 25]). But if the process of torus shifting due to ageing is gradual in general, it nevertheless shows certain deviations. Some of them may be attributed to special conditions, under which the annual rings, singly or in groups (e. g. columns 4,11 and 14 in Table 1), have made their development; others are caused by peculiar changes of the ageing wood. A striking case in point is the sharp decrease of the percentage of active pits when sapwood is passing into the state of ripe wood ([11, 13]) (Table 2).

Comparing these figures with the results of other investigations dealing with ripe wood ([4, 7–9]), we come to the conclusion that as in ours so in several

Table 2

Change in the Position of Tori on the Appearance of Ripe Wood

Species	Condition of wood	Percentage of tori			
		located centrally	shifted	almost adjoining	close to aperture
Picea orientalis	Sapwood	68.5	23.1	6.8	1.6
	Ripe wood	2.1	5.4	9.0	83.5
Abies Nordmanniana	Sapwood	78.6	9.5	6.9	5.0
	Ripe wood	4.5	9.4	7.0	79.1

other woody species ([8],[10],[19]) there is a sudden increase in the intensity of the wood ageing process which gives rise to the phenomenon of «ripe wood».

7. A great difference is observed when the age related shiftings of tori as they take place in *Picea* and *Abies* growing in their natural surroundings (Bakuriani) are compared with those in foreign species raised in the Botanical Gardens at Tbilissi. In the first two species the tori were found to have changed in position very little in the course of the first 20—30 years; contrary to this, in the second group (*Picea Morinda* and *Picea* sp.; *Abies cephalonica* and *A. cilicica*; *Pinus Strobus* and *Cedrus Deodara*) a very early and rapid decrease in the number of active pits was observed for the same period of life ([12]). It is very likely that in the latter case the conditions of an uncongenial climate had accelerated the ageing processes in the wood, and contributed to an early weakening of its water conducting power.

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Received
2.II.1941.

REFERENCES

[1] В. Арциховский, Тр. по лесному опытному делу, XI (1931). [2] В. Арциховский, Н. Красулин и Б. Сахаров, там же. [3] И. Бородин, Курс анатомии растений, Л. (1938). [4] Н. Брегадзе, Тр. Тбил. бот. ин-та, IV (1938). [5] С. Ванин, Древесиноведение, Л. (1934). [6] С. Ванин, Л. Баженова и Н. Прикот, Тр. Лесотехн. акад., 48 (1937). [7] Л. Джапаридзе, Тр. Тифл. бот. ин-та, I (1933). [8] Л. Джапаридзе, Дендрология Курдиани, Тбил. (1934). [9] Л. Джапаридзе, Природа, 9 (1936). [10] Л. Джапаридзе, Тр. Тбил. бот. ин-та, II (1937). [11] Л. Джапаридзе и Н. Брегадзе, Бот. журн. СССР, № 4—5 (1940). [12] Л. Джапаридзе и Н. Брегадзе, Сообщ. Груз. фил. АН СССР II, 1—2 (1941). [13] Л. Джапаридзе и Н. Брегадзе, Тр. Тбил. бот. ин-та, VIII (1941). [14] Ф. Крашенинников, Лекции по анат. раст., М. (1937). [15] Д. Лекторский, Пропитка древесины (1940). [16] В. Любименко, Зап. Имп. Никит. сада, VI (1914). [17] I. Bailey, Bot. Gazette, 62 (1916). [18] S. Buckman, H. Schmitz and R. A. Gortner, Jnl. Phys. Chem., 39 (1935). [19] L. Djaparidze, Forstwissenschaftl. Zentralbl., 12 (1936). [20] D. Erickson, H. Schmitz and R. A. Gortner, Jrnl. of Agric. Res., LVI, 10 (1938). [21] G. Griffin, Jrnl. Forestry, 17 (1919). [22] G. Griffin, ibid., 22 (1924). [23] E. Jeffrey, The anatomy of woody plants, 56, Chicago (1926). [24] J. MacLean, Am. Wood-Preserv. Assoc. Proc., 24 (1928). [25] E. Phillips, Forestry, VII (1933). [26] G. Scharth, Paper Trade Jrnl., 86 (1928). [27] G. Scarth and J. Spier, Roy. Soc. Canada Trans., 23 (1929). [28] J. Sutherland, H. Jonston and O. Maass, Canad. Jrnl. Research, 10 (1934).

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PLANT BREEDING

SELECTION AFTER ELEMENTAL CHARACTERS IN PLANT BREEDING

By A. N. IPATIEV

(Communicated by A. A. Richter, Member of the Academy, 2.II.1941)

Within recent years we have adopted a new method in breeding tomato plants for earliness. We have named it selection after elemental characters. This method is based on the theory of ectogenetic adaptive evolution, as suggested by A. N. Sewertzoff [1]. According to this theory the evolution, if represented schematically, runs as follows:

Environment	Organisms		
Change in a certain group of environmental conditions	Adaptation of those ectosomatic organs which are functionally connected with the conditions concerned (protollaxes)	Adaptation of those entosomatic organs which are functionally connected with the modified ectosomatosic organs (deutollaxes)

With reference to plant breeding the general order in the run of evolution can be changed only so far as it is possible by a planned and steady selection of protollaxes to speed up the whole process and give it, to a certain extent, a desirable direction.

Accordingly, the selection after elemental characters must begin from analyzing the constitutional changes in the organism which are striven for. After one has found out that combination of protollaxes which brings about the aromorphosis desired, one makes further selection among these protollaxes, always aiming at the deep changes which one has in mind.

Let us now take a look at this method when it is applied in practice to the selection of tomatoes, *Lycopersicum esculentum* Mill.

Plants in general and tomatoes in particular are described by characters of different kind. There are complex characters which are made up by some elemental ones. Thus, in the case of tomatoes the productivity is composed of the following simple characters: 1) number of flower racemes on a plant, 2) number of fruits in a cluster, 3) size of fruits, 4) weight of fruits, 5) rate of development of the racemes, etc. Another character, earliness, also falls [2-4] into a number of more simple characters. These are as follows: 1) elevation of the first flower raceme, 2) spacing of the flower racemes on the stem, 3) rate of development of the flower racemes (related to their structure), 4) rate at which the fruits pass their different ripening phases (green, pale-yellow, red-brown, ultimate).

Investigation of the world collection of forms and varieties within the species *Lycopersicum esculentum* Mill. has taught us how to make our choice of the simple characters in order to produce a most early ripening variety. Those plants, which set their first flower raceme at the lowest possible height, have the fruits of this raceme red at the earliest date. Most tomato plants set their first flower raceme under the 9th true leaf. But some set it higher (over the 10–15th true leaf) and other again set it lower. Among the specimens of the world collection we have encountered plants that had their first flower raceme under the 6th or even 4th leaf, which is very

low indeed. It will be obvious that in breeding for an early ripening variety we have to select plants with the least elevated first flower raceme.

It has been shown further by our study of the world collection of tomatoes, as well as by the American worker Yeager ([5]) that earliness in tomatoes depends also upon how dense is the spacing of the flower racemes on the plant. In most varieties the racemes alternate with three leaves. There are three leaves between the first raceme and the second; another three leaves between the second and the third, and so on. But some varieties and plants have their racemes separated by one or two leaves only. And there are others which have no leaves at all between their racemes. We have reported the latter as the highest determinate type ([3]). So in breeding for earliness the spacing of the blossom racemes is an important consideration, too.

Then we have found that the rate of development of the racemes is also related to earliness. In different varieties and plants of tomato the racemes develop at a very different rate. Plants with rapidly developing racemes should be preferred while selecting for earliness, but one must not lose sight of the above two characters: the elevation of the first blossom raceme and the length of the interval between the racemes. It is also important to pick out those plants whose fruits quickly pass the ripening phases. In this respect there is a great diversity of forms within the species *Lycopersicum esculentum* Mill., and one of its variety, Surprise of Devon, is even lacking the green phase at all. We shall not linger here over environmental factors (fertilization, photoperiodism, heat, etc.) or agrotechnical measures which certainly have a definite influence on earliness.

To sum up, it is well to stress that the first stage in selection after elemental characters is thoroughly to study the variation within a given species in order to find out those elemental modifications which will make up the intended constitution of the plant. These elemental modifications are described by us conventionally by the name of protollaxes, since they are undoubtedly the first response of the organism to the environmental influence. What their combination may bring about in the constitution of the plant, is a secondary change. In order to make the elemental characters combine and call forth the desired modification of a complex character (or what we call aromorphosis), we have to pick them out according to our breeding plan, making use (in the case of tomatoes) of individual selection. Persistent selection of plants with desirable elemental characteristics will surely lead to deep changes in the whole constitution of the plant.

We were successful to obtain very early ripening plants in that way. They were also remarkably short lived. In their nature, tomatoes are perennial plants, but they are killed every autumn by the frost. If transferred for the cold season to the hothouse, they will live several years. Our ultra-early tomatoes die away after ripening in the first year of life. The several strains gave 100% of ripe fruit as early as August 15—20 (1939), after being planted at the usual date. And they were dead before the advent of frost.

Similar work is now being carried on with water-melons by N. N. Lissin. He has not yet come to final results, but some shifts toward earliness have also been obtained by him.

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REFERENCES

[1] А. Н. Северцов, Морфолог. закономерности эволюции (1939). [2] А. Н. Ипатьев и А. В. Гаенко, Тр. ОмСХИ им. С. М. Кирова, XVII (1939). [3] А. Н Ипатьев, Докл.ВАСХНИЛ, вып. 10 (1939). [4] А. Н. Ипатьев, Сортовые ресурсы томат (1940). [5] A. F. Yeager, N. Dakota Agr. Exp. St., Bull. 276 (1933).

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ZOOLOGIE

DIE ADAPTIVE MORPHOLOGIE DER SPECHTE

Von L. P. POSNANIN

(Vorgelegt von I. I. Schmalhausen, Mitglied der Akademie, den 31.X.1940)

Die vorliegende Arbeit war schon im Jahre 1936 ([8]) abgeschlossen, wurde aber später durch neue Befunde etwas ergänzt ([9]). Wenn die Literatur über die Spechte im allgemeinen reich ist, so gibt es doch wenig Untersuchungen, welche den Bau im Zusammenhang mit der Ökologie aufklären ([5], [12], [16]). Burt ([1]), welcher die Ernährung und die damit in Verbindung stehende Eigentümlichkeiten des Baues der nordamerikanischen Spechte untersuchte, hat zugleich auch eine ökologische und morphologische Formenreihe aufgestellt. Indem wir uns die Aufgaben gestellt haben einige Fragen der Morphologie, besser gesagt, der ökologischen Morphologie, aufzuklären, haben wir in dieser Untersuchung in gewissem Masse die Arbeit von Burt ([1]) an den Spechten der Fauna der UdSSR wiederholt (die untersuchten Arten—siehe Schema).

Für die Spechte können vier ökologische Eigentümlichkeiten festgestellt werden: 1) Klettern auf vertikaler Oberfläche oder Krallenklettern, 2) Meisseln oder Hacken für die Freilegung der Nahrung und der Einrichtung von Nisthohlen, 3) eigenartige Ergreifung der Nahrung mit der Zunge, und 4) Nisten in ausgemeisselten Baumhöhlen.

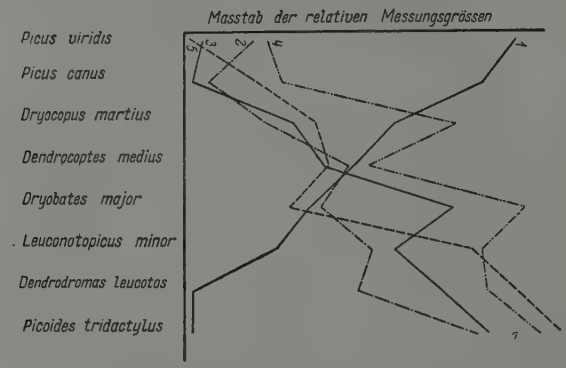
Die Spechtfüsse wurden ausführlich von Scharnke ([12]) untersucht. Das Krallenklettern ist mit einer Reihe von Umbildungen des zygodaktylen Fusses verknüpft, aber innerhalb der *Picinae* sind die Veränderungen dennoch nicht gross. Der Körper der Spechte ist auf senkrechter Oberfläche äusserst standfest. Dies betrachten wir als frontale (in der Kopf-Schwanzrichtung) und Seitenstandfestigkeit. Die erste wird durch den Stützschwanz gesichert, und die zweite durch die breite Auseinanderstellung des Fusses, die Abspreizbewegung der IV Zehe und die Ausbreitung der Steuerfedern bei der Stütze auf den Schwanz. Die frontale Standfestigkeit ist für das effektive Hacken und die sprungartigen Bewegungen des Spechtes notwendig, die Seitenstandfestigkeit für die Seitenbewegungen und für Wendebewegungen des Kopfes bei der Nahrungsaufnahme (*Dryocopus*).

Die Untersuchung der Ontogenese des Spechtfusses zeigt, dass: 1) die Formierung der Zygodaktylie sehr früh, während der Embryogenese, entsteht, 2) findet eine Rekapitulation des anizodaktylen Fusses statt und 3) fällt die Zeit der Formierung des letzteren bei den Spechten in frühere Stadien, als bei den anderen Vögeln, wo dies eine Definitiveerscheinung darstellt; diese Acceleration erklärt sich durch die spätere Bildung des zygodaktylen Fusses (ein Beispiel der s. g. Tachygenese). Bei der Entwicklung

des Fusses des Dreizehenspechtes rekapituliert der anyzodaktyle Fuss, und nicht der zygodaktyle Fuss, da ja die I Zehe früher reduziert, als sich die IV nach hinten wendet (negative Archallaxis).

Das Schwanzgebiet hat im Zusammenhang mit dem Krallenklettern starke Umbildungen erfahren. Das Pygostyl charakterisiert sich: durch eine Verkleinerung der neuralen Fortsätze, einer vergrösserten Terminalplatte, durch ein breiteren Oberrand, kräftige Leitenfortsätze. Es ist im allgemeinen mehr massiv und vergrössert. Die Untersuchung des Pygostyls des Wendehalses zeigt, dass die Vorfahren der *Jynginae* auf vertikaler Oberfläche kletterten.

Die Befestigung der Steuerfedern am Pygostyl schränkt die Schwanzausbreitung stark ein (der m. pubo-coccygeus, welcher die Schwanzausbreitung fördert, wird ebenfalls reduziert), was für die Stützfunktion des Schwan-



Die Veränderungen einiger Merkmale in der Reihe der Spechte, von dem weniger meisselnden *Picus viridis* zu dem am meisten meisselnden *Picoides tridactylus* (der Masstab ist für jede Kurve verschieden)*: *1*—Winkel zwischen der Fläche des for. occipitale und der Schädelbasis, *2*—interorbitale Breite Frontale, *3*—Breite der internasalen Scheide, *4*—Breite des Unterschnabels bei symphysis, *5*—Grösse der Terminalplatte des Pygostyls.

zes sehr wichtig ist. Alles dies zusammen mit den bekannten Veränderungen im Bau der Steuerfedern, macht den Schwanz wenig brauchbar als Steuer in der Luft (Unvollkommenheit des Fluges der Spechte)—ein Beispiel des Prinzips des Funktionswechsels (²). Im allgemeinen sind die Organe, welche mit dem Klettern in Verbindung stehen, bei den untersuchten Formen wenig veränderlich, was auf die Beständigkeit der Klettergewohnheit hinweist.

Das Kopfgebiet hat sich besonders stark umgebildet. Unsere Spechte können in eine ökologische Reihe, von den am wenigsten bis zu den mehr meisselnden Arten eingeordnet werden (siehe Schema). Nach dem Bau ihres Schädels und Schnabels, kann eine morphologische Reihe gebildet werden, welche mit der ökologischen Reihe zusammenfällt. In dieser Reihe kann folgendes festgestellt werden: die Verschiebung des for. occipitale magnum auf die Ventralseite des Schädels, das Auswachsen der Gehirnhöhle nach vorne, die Bildung von Falten am os frontale und eine Krümmung ihrer Verbindungslinie mit der praemaxilla, die Vergrösserung der Interorbitalbreite des frontale, die Verdickung des septum interorbitale, die Vergrösserung der Breite und Verringerung der Höhe der Schädelhöhle, die Gesamtvergrösserung des Schädels, die Verringerung des Kranial-facialwinkels, das

Verschwinden des Stirnhockers, die Vergrösserung der internasalen Breite des praemaxilla; die hornige Oberschnabelbedeckung ist mehr geschliffen, die Krümmung des Schnabels ist geringer, die hornige Schnabelumkleidung ist stärker ausgebildet, die Verlängerung der symphysis des Unterkiefers und die Stabilisierung ihrer Lage, die Vergrösserung des Terminalschnittes des Schnabels, allgemeine Verkürzung und Breiterwerden des Schnabels, die Verstärkung der Befiederung der Nasenlöcher, die Verringerung ihrer Grösse bei dem Übergang zur vertikalen Haltung usw.—sind weitere Kennzeichen. Alles dies verwandelt den Schnabel und den Schädel viel meisselnden Arten in ein vollkommenes Werkzeug für den Schnabelhieb. Manche Züge im Bau stehen aber im Zusammenhang mit der ökologischen Eigenart der einzelnen Arten: so sind bei *Dryocopus* und *Picus viridis* in Verbindung mit starken Seitenbewegungen des Kopfes die Nackenkämme entwickelt, bei *Dryobates* ist im Zusammenhang mit dem Körnerfressen der Schnabel stumpf.

Für ein effektives Hacken ist eine möglich vollständige Unbeweglichkeit des Schnabels in bezug auf den Schädel notwendig. Dies wird durch die starke Gedrängtheit der Kiefer gesichert (normale Entwicklung der Kiefermuskulatur, obgleich der Schnabel zum Ergreifen der Nahrung nicht angewandt wird). Der Hackakt selbst ruft eine maximale Befestigung des Schnabels während des Hiebes hervor. Das Hacken ist der primäre und hauptsächliche Faktor bei der Schädelumbildung der Spechte. In dem Schädel lassen sich auch die Bahnen der Tätigkeit der mechanischen Kräfte bestimmen: die grösste Wirkung geht durch die internasale Scheide in das Frontal-Orbitalgebiet, weniger durch den Unterkiefer und der ossa quadrata. Geringer ist die Wirkung durch das Backenbein und das Gaumenbein. Die Untersuchung des Schädels von *Jynx torquilla* zeigt, dass die *Jynginae* niemals mit dem Schnabel meisselten.

Der Bau des Kopfgebietes der Spechte zeigt bei den untersuchten Formen äusserst grosse Veränderlichkeit (Schema); besonders die Struktur der hornigen Schnabelbedeckung [ein Beispiel eines «ektosomatischen Organs»([11])]. Es gelang uns zu zeigen, dass diese Struktur phylogenetisch jünger ist und sich schneller verändert, als die Knochenbasis des Schnabels und der Schädel selbst, welche als entosomatische Organe angesehen werden.

Das Halsgebiet ist bedeutend geringer verändert. Vor allem müssen wir auf die bis jetzt noch nicht erforschte, eigenartige Verstärkung der m. longus colli anticus hinweisen, ähnlich wie dies der Fall ist bei den von Garrod ([4]) beschriebenen Anchynge. Bei den Spechten (besonders bei den mehr meisselnden) bildet sich aus einem bandartigen Muskel ein mächtiger Muskel mit kurzem Bauch und langen Sehnen. Das vergrössert die Schnelligkeit und die Stärke seiner Kontraktion bei dem Schnabelhieb.

Das Schwanzgebiet hat sich im Zusammenhang mit dem Meisseln stark umgebildet. Die Veränderungen seines Baues erlauben eine morphologische Spechtreihe aufzustellen, welche mit der Reihe des Baues des Kopfgebiets, sowie auch mit der ökologischen Reihe zusammenfällt (Schema). Es ist klar zu sehen, dass eine Korrelation nicht nur zwischen den Eigenarten des Baues und der Ökologie besteht, sondern auch zwischen dem Bau zweier verschiedener Körperteile [biologische Koordination ([14], [15])]. Bei dem Übergang von weniger zu mehr meisselnden Arten können folgende Veränderungen festgestellt werden: die Vergrösserung des Pygostyls, die Vergrösserung der Terminalplatte, die Zuspitzung ihres oberen und breiter werdenden unteren Randes, die Verkleinerung der Neuralplattenlänge, die Schwächung der lateralen Schwanzmuskulatur (m. m. ischio-femuri und pubi-coccygeus), bei der Verstärkung der medialen Muskulatur (m. depressor coccygis) und eine weitere Einschränkung der Schwanzausbreitung. Alles dies, und die weitere Umbildung des Schwanzes selbst, hat eine negative Bedeutung für

den Flug der Spechte. Die typishe Hackspechte sind ausgesprochene Standvögel und haben nicht das Bedürfnis weite Wanderungen zu unternehmen, da sie auch im Winter leicht die versteckte Nahrung erreichen.

Während der postembryonalen Entwicklung des Pygostyls der Spechte (*Dryobates*) kann eine eigenartige «Funktionsrekapitulation» des typischen Vogelpygostyls beobachtet werden: die Ossifikation geht zentrifugal vor sich, so dass bei dem jungen Vogel nur der mediale feste Teil der Terminalplatte eine Bedeutung für die Stütze der Steuerfedern hat. Zu dieser Zeit ist sie der Form nach der Terminalplatte des gewöhnlichen Vogelpygostyls ähnlich. Ausserdem findet sich auch eine teilweise Rekapitulation des Pygostyls der nächsten Vorfahren der *Picidae*: während der Ontogenese wird die rhombenähnliche Form durch eine rechteckige ersetzt.

Im allgemeinen muss gesagt werden, dass im Zusammenhang mit der Veränderlichkeit des Meisselns in der Spechtreihe, auch der Bau der damit verbundenen Organe äusserst variabel ist. In diesen Organen kann ein einheitlicher Prozess der Konzentration der Elemente beobachtet werden, d. h. eine Abschwächung der lateral liegenden und eine progressive Entwicklung der medial liegenden Teile und Strukturen. Dies steht in Verbindung mit der Eigentümlickeit des Hackens selbst, welches als eine Serie schroffer Stösse angesehen werden kann (Analogie—Konzentration der Elemente in den Extremitäten der laufenden und springenden Säugetiere).

Die Zunge der Spechte hat sich ebenfalls sehr stark umgebildet ([7], [6], [3], [13] und andere). Es ist wichtig, dass in der Formenreihe der Bau der Zunge und des Zungenbeinapparates sehr veränderlich ist.

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ZITIERTE LITERATUR

[1] W. Burt, Univ. of Cal. Publ. in Zool., **32** (1930). [2] Dohrn, Der Ursprung d. Wirbeltiere u. das Prinzip des Funktionswechsels (1875). [3] Gardner, Proc. U. S. Nat. Mus., **67** (1925). [4] A. Garrod, Proc. Zool. Soc. Lond. (1876). [5] K. Kessler, Bull. Soc. Nat. Mosc., **17** (1844). [6] Leiber, Zoologica, H. 51 (1907). [7] Lucas, U. S. Dept. Agr. Bull., **7** (1895). [8] Л. Познанин, Морфология приспособит. признаков дятлов (1936). [9] Л. Познанин, Экологич. морф. птиц древесн. специализации, диссерт. (1940). [10] L. Posnanin, C. R. Acad. Sci. URSS, XXXI, No. 2 (1941). [11] A. N. Sewertzoff, Morphol. Gesetzmässigkeiten d. Evolution (1931). [12] Scharnke, Journ. f. Orn., **78** (1930). [13] Scharnke, ibid., **79** (1931). [14] И. И. Шмальгаузен, Основы сравнит. анатомии (1935). [15] И. И. Шмальгаузен, Пути и закономерности эволюционного процесса (1939). [16] M. Stolpe, Journ. f. Orn., **80** (1932).

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ZOOLOGIE

ÜBER DIE EVOLUTION DER SPECHTE

Von L. P. POSNANIN

(Vorgelegt von I. I. Schmalhausen, Mitglied der Akademie, den 31.X.1940)

Im Verlauf einiger Jahre wurden von uns die adaptiven Besonderheiten des Baues der Spechte und ihr Zusammenhang mit den ökologischen Eigentümlichkeiten dieser Vögel untersucht. Die erhaltenen Ergebnisse ([6]) erlauben uns einige Erwägungen über die Evolution der *Picidae* zu äussern.

In der Phylogenese der Spechte entwickelte sich wahrscheinlich zuerst das Krallenklettern, und erst später das Hacken und das Ergreifen der Nahrung mit der Zunge. Die Erforschung der Postembryoadaptationen [Schnabelform, die warzigen Sohlen ([4])] nicht nur der Spechte, sondern auch anderer versteckt nistender Vögel, so wie auch die Entwicklung des Daunenkleides der Jungen und die Eierfarbe, erlauben ein Urteil über das Alter der versteckten Nistform, und in bestimmten Masse über den Verwandschaftsgrad der Spechte mit anderen ihnen nahestehenden Vogelgruppen zu fällen. Gadow ([3]) stellt die Gruppe der *Pici* den Eisvögeln (*Alcedinidae*) nahe. Dies ist richtig, da unter anderem beide Gruppen sich durch ähnliche Schnabelform während der Ontogenese (unterkiefer Prognathismus) auszeichnen, was zusammen mit dem Verlust des Daunenkleides der Jungen und der Eipigmentation zeigt, dass das versteckte Nisten bei ihnen eine alte Form ist.

Burt ([2]), indem er sich auf die Regel über die Reduktion des hallux bei den Laufenvögeln ([1]) bezieht, nimmt als Vorfahren der Spechte auf dem Boden laufende Formen an. Dieser Annahme können wir nicht zustimmen, da doch die Reduktion des hallux bei den Spechten mit dem Krallenklettern in Verbindung steht ([5]). Wir denken, dass die Ahnen der Spechte klammerkletternde Waldvögel waren (wir erinnern dabei an die Lebensweise der tropischen Vögel, wie *Halcyon* und *Dacelo*, und unter den *Pici* an die den Spechten nahestehenden *Capitonidae*). Ein Beweis dafür kann die Zygodaktylie der Spechte liefern, welche sich gewöhnlich in Zusammenhang mit dem Klammerklettern entwickelt; bei den Spechten wird sie sogar teilweise infolge des Krallenkletterns gestört («Abspreizbewegung» der IV Zehe).

Der Übergang zum Krallenklettern hatte eine grosse Bedeutung für die Evolution dieser Familie, dadurch wurden ihnen neue ökologische Standorte (vertikale Oberflächen) gesichert, welche anderen Vögeln verschlossen blieben. Für ein effektives Erwerben der hier lebenden Insekten, war es nicht nur wichtig sich für eine Zeit auf der Baumrinde zu halten (was auch z. B. die Meisen öfters tun), sondern sich auch auf ihr weiter zur Aufsuchung des Futters zu bewegen.

Parallel mit der Entwicklung des Krallenkletterns verlief auch die Anpassung zur Nahrungsgreifung. Da die Zunge der den Spechten naheste-

henden *Alcedinidae* und *Capitonidae* kurz ist, ist auch kein Grund anzunehmen, dass die Zunge der Spechtahnen bei ihrem Übergang zum Krallenklettern eine andere war. Wahrscheinlich haben sie auch deswegen in der ersten Zeit die Nahrung mit dem Schnabel ergriffen. Es ist bekannt, dass der Schnabel der *Alcedinidae* und *Capitonidae* ziemlich dick ist, was wahrscheinlich auch bei den Vorfahren der Spechte der Fall war. Aber ein dicker Schnabel war wenig geeignet die Insekten aus den Baumrinderitzen herauszuholen, weshalb auch letzten Endes diese Funktion von der Zunge übernommen wurde. Die Anpassung an das Herausholen der in Gängen verborgenen Insekten mit einer verlängerten Zunge, die eine proximal gerichtete Rauhigkeit erworben hatte, war die zweite Hauptetappe in der Evolution der Spechte. Hier ist die Abhängigkeit der Richtung der Evolution von dem morphologischen Ausgangszustand des Organismus klar zu sehen. Wenn in analogen Bedingungen Formen mit feinem Schnabel gewesen wären, so hätte sich wahrscheinlich im Evolutionsprozess der Schnabel an das Herausholen der Nahrung angepasst (wie bei *Certhiidae* und vielen *Dendrocolaptidae*).

Indem die Vorfahren der Spechte die in Baumrinden und Baumstämmen verborgenen Insekten als Nahrung ausnützten, entwickelte sich bei ihnen nicht nur die Fähigkeit dieselben mit der Zunge herauszuholen, sondern dabei auch die störende Rindestücke mit dem Schnabel zu entfernen (Entwicklung der Hackfähigkeit). Letztere wurde durch die genannte Eigenschaft des Spechtschnabels (massiv) gefördert. Die Entwicklung der Meisselfähigkeit war die dritte Hauptetappe in der Evolution der Spechte. Es ist bekannt, dass einigermassen stark nur die krallenkletternden Vögel meisseln. Wahrscheinlich schafft die senkrechte Haltung des Körpers für die lokomotorische Funktion des Halsgebiets die besten Bedingungen (Schwungbewegungen, wie die eines Pendels). Ausserdem ist ein effektives Hacken nach Nahrung nur bei grosser Standfestigkeit des Körpers möglich (6),was aber nur beim Krallenklettern (Stützschwanz) gesichert wird. Folglich konnte das Hämmern nur nach bedeutend fortgeschrittener Entwicklung des Krallenkletterns entstehen (der Umstand, dass die Kleiber ohne Stützschwanz meisseln, besagt noch gar nichts, da ja in diesem Fall das Körpergewicht des Vogels sich scharf von dem des Spechtes unterscheidet). Die Greiffunktion der Zunge steht mit solchen Bedingungen nicht in Verbindung und entwickelte sich wahrscheinlich früher, näher der Entstehungszeit des Krallenkletterns.

Nach dem Übergang zum Krallenklettern, ging die Evolution der *Picidae* in zwei verschiedenen Richtungen vor sich. Die eine Formen erwarben ausser der Fähigkeit die Nahrung mit der Zunge zu ergreifen, auch die Hackfunktion des Schnabels. Dies waren die Ahnen der *Picinae*. Die anderen—die Ahnen der *Jynginae*—erwarben im Prozesse der Evolution die spezielle Fähigkeit die Zunge als Nahrungsgreifapparat auszunützen, wobei die Nahrung an dem langen proximalen Teil der Zunge anklebt. Ihre Beute wurden hauptsächlich die Ameisen, welche auch leicht auf dem Boden zu bekommen waren. Letzteres führte zum Verlust der Krallenkletterfähigkeit (die Untersuchungen des Pygostyls und des Schädels der *Jynx* zeigen, dass ihre Vorfahren auf der senkrechten Oberfläche kletterten, aber niemals die Fähigkeit zum Meisseln besassen).

Die Evolutionsrichtung der *Picinae* hat sich, nachdem die Hackfähigkeit bis zu einem gewissen Grad entwickelt war, ebenfalls geteilt. Die grösste Anzahl der Formen entwickelte maximal das Hacken («Hackspechte») Eine weit geringere Zahl von Formen entwickelte gleich, wie die *Jynginae*, die Zunge, sie suchen ihre Nahrung hauptsächlich auf dem Boden, verloren aber die Krallenkletternfähigkeit nicht («Erdspechte»—*Picus*). Die geringe Anzahl der «Erdspechte» und *Jynginae* erlaubt anzunehmen, dass die Anpassung der Zunge für die Nahrungsgreifung nicht der Weg eines biologischen

Fortschrittes ist, während die Entwicklung der Hackfähigkeit eine stürmische adaptive Radiation der *Picinae* bedingte (die grösste Anzahl der Arten sind «Hackspechte»).

Von den gemeinsamen Vorfahren der Hackspechte, haben sich relativ früh die Ahnen der *Dryocopus* abgezweigt, welche später die Fähigkeit entwickelten den Schnabel als Hebel für die Abbröckelung der Rinde und des Holzes zu verwenden. Die stärkste Meisselfähigkeit entwickelte sich bei den Buntspechten, also Arten, welche sich erst später differenzierten. *Dryobates major* hat eine für die Spechte ungewöhnliche Eigenschaft (Körnerfressen) erworben. Die höchste Äusserung der Meisselfähigkeit finden wir bei den *Picoides*.

Wir haben gezeigt, dass die Evolution der meissten Spechte auch jetzt noch in der Richtung der weiteren Vervollkommnung der Hackfähigkeit vor sich geht. Dies wird dadurch gefördert, dass alljährlich frische Baumhöhlen gezimmert werden. Die Ausnützung der Baumhöhlen für das Brutgeschäft hat eine Reihe Vorzüge. Indem wir den Standpunkt einnehmen, wonach die Klasse der Vögel von den auf Bäumen lebenden Formen abstammt, so müssen wir die Familie der Spechte als äusserst spezialisierte Gruppe der ursprünglichen Baumvögel betrachten, bei welchen die Anpassung an die Lebensweise auf Bäumen, seit der Entstehung der Vögel überhaupt, weiter geht.

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ZITIERTE LITERATUR

[1] A b e l, Verh. zool.-bot. Ges., Wien, **61** (1910). [2] B u r t, Univ. of Calif. Publ. in Zool., **32** (1930). [3] H. G a d o w, Bronn's Klassen usw., **6** (1893). [4] Л. П о з н а н и н, Зоол. журн., **17** (1938). [5] Л. П о з н а н и н, Экологич. морфология птиц древесн. специализации, диссерт. (1940). [6] L. P o s n a n i n, C. R. Acad. Sci. URSS, XXXI, No. 2 (1941). [7] S e w e r t z o f f, Jen. ZS. f. Nat., **63** (1927). [8] А. Н. С е в е р ц о в, Морфол. закономерн. эволюции (1939).

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EXPERIMENTELLE MORPHOLOGIE

RELATIVE BEDEUTUNG DER AUSSEN- UND INNENSCHICHT DER NEURALPLATTE BEI DER BILDUNG DES NEURALROHRS SCHWANZLOSER AMPHIBIEN

Von T. DETTLAFF

(Vorgelegt von I. I. Schmalhausen, Mitglied der Akademie, den 3.II.1941)

In meiner letzten Arbeit (1) gelang es mir, in der Neuralanlage schwanzloser Amphibien im Frühgastrulastadium die Aussen- und Innenschicht der Neuralplatte zu scheiden, deren Schicksal im Neurulationsprozess sich verschieden erwies. Die Ergebnisse dieser Arbeit bestätigten den bereits ausgesprochenen Gedanken, dass die Aussenschicht die Innenfläche des Neuralrohrs, während die Innenschicht den Hauptteil von dessen Wänden bildet.

Jedoch war dieser Schluss kein direktes Resultat der Arbeit; er gründete sich sowohl auf dem Benehmen der erwähnten Teile unter Isolationsbedingungen, als auch auf Bildern normaler Entwicklung. Deshalb war es von Interesse das Verhalten der Neuralplattenschichten unter solchen Experimentalbedingungen zu beobachten, die näher zu typischen Bedingungen stehen. Solche Bedingungen bietet das Experiment des Ersatzes der Aussenschicht der Neuralplatte des Embryo einer gewissen Gattung durch die Aussenschicht der Neuralplatte, die bei dem anders pigmentierten Embryo einer anderen Gattung genommen wird. Bei einer glatten Anheilung muss die Entwicklung harmonisch vor sich gehen, und zu gleicher Zeit muss der Unterschied in der Zellenpigmentierung die relative Position der Bildung der Innen- und Aussenschicht unter Bedingungen deren gemeinschaftlicher Entwicklung feststellen lassen. I n Versuchen den Ersatz zwischen verschiedenen Gattungen auszuführen, als gelungen erwiesen sich nur folgende: *R. temporaria*→*R. esculenta*, *Bufo vulgaris*→*R. esculenta*, *R. temporaria*→*Pelobates*. Die Kombinationen *Pelobates* mit *Bufo* gelangen mir kein einziges Mal, weil das transplantierte Gewebe des *Bufo* nach kurzer Zeit Erscheinungen des Zerfalls im umgebenden Gewebe des Wirtes hervorrief.

Ein Teil der hier beschriebenen Experimente gehört zu der Saison 1938; die Transplantation der Aussenschicht der Neuralplatte ist von *Bufo vulgaris* auf *R. esculenta* durchgeführt worden. Der zweite Teil, der zur Aufklärung der relativen Bedeutung der beider Schichten für die Bildung des Auges aufgestellt wurde, fällt in die Saison 1940 und ist mit der Kombination *Pelobates*→*R. temporaria* durchgeführt worden. In diesem Falle wurden die Embryonen bis zu späteren Stadien gezüchtet, und zwar bis zum Stadium der verlängerten Schwanzknospe oder des sich bereits ausdehnenden Schwanzes. Die erzielten Resultate bedürfen noch einer Nachprüfung, da das Prozent gelungener Anheilungsfälle unbedeutend war; doch sind die erhaltenen Anheilungsfälle an sich schon belehrend genug, um auf deren Basis vorläufige Schlüsse ziehen zu können.,

Das Experiment bestand in folgendem. Bei Embryonen von *R. esculenta* oder *Pelobates* wurde im Spätgastrulastadium eine Parzelle der Aus-

senschicht im Gebiet der künftigen Neuralplatte ausgeschnitten, von der unterliegenden verdickten Innenschicht getrennt und entfernt. Auf analoge Weise wurde eine entsprechende Parzelle bei Embryonen von *R. temporaria* oder *Bufo* in demselben oder in einem etwas späteren Stadium (nicht später als im 13. Stadium nach Harrison) ausgeschnitten; nach sorgfältiger Reinigung derselben von einzelnen anhaftenden Innenschichtzellen wurde sie schnell auf die entblösste Innenschicht der Neuralplatte der Embryonen von *R. esculenta* oder *Pelobates* aufgetragen. Um ein glattes Anwachsen des Transplantats an die unterliegende Schicht zu erzielen, wurde der Embryo unmittelbar nach dem Auflegen des Transplantats mit der Rückseite nach unten gekehrt, damit er mit dem eigenen Gewicht das Transplantat andrückte; in einigen Fällen wurden dafür Glasbrücken angewandt.

In Fällen eines glatten Anwachsens des Transplantats beteiligte es sich harmonisch am Neurulationsprozess, und, wie ich auch vorausgesetzt hatte, rief seine Anwesenheit keine äusserlich zu beobachtenden Abweichungen vom Normalprozess hervor. Die transplantierte Aussenschicht rollte sich ebenso zusammen und sank ebenso hinein, wie die Aussenschicht der Neuralplatte bei einem nichtoperierten Embryo. In einigen Fällen zog sich das Transplantat im Prozess der Neurulation sehr stark in die Länge, was den lokalen Neurulationsbewegungen entspricht (²). Hier ist es gelegen zu sagen, dass in meinem anderen Experiment, dessen Beschreibung nicht in den Inhalt der vorliegenden Arbeit gehört, und in dem auf ebensolche Weise die Aussenschicht des ventralen Epithels einer Spätgastrula auf die entblösste Innenschicht der Neuralplatte transplantiert wurde, dieses harmonische Einschliessen des Transplantats in den Neurulationsprozess nicht stattfand.

In der Serie *Bufo*⟶*R. esculenta* wurden im ganzen 14 gelungene Operationen gemacht. Auf diese Zahl blieb in 3 Fällen das Transplantat ausserhalb der Neuralplatte; in 4 Fällen, in den das Transplantat sich eingestülpt hatte, war es doch im Fixationsmoment (Stadium der Frühschwanzknospe) schon zerfallen; in 2 Fällen blieb das Transplantat in gutem Zustande, schloss sich jedoch nicht harmonisch ein und lagerte sich in den oberflächlichen Teilen des Nervensystems; das letztere hat dabei eine atypische Struktur: ihm fehlt die Höhle. Nur in 3 Fällen schloss sich das Transplantat mehr oder weniger harmonisch in den Neurulationsprozess ein. In diesen Fällen pflastert es in mehreren Schnitten die Höhle des Neuralrohrs, und seine einzelne Zellen sind von länglicher Form und verbreiten sich von der inneren bis zur äusseren Oberfläche des Neuralrohrs, d. h. sie haben eine für Spongioblasten charakteristische Form, wie die letzteren von His (³) beschrieben werden. Diese Zellen sind in allen Fällen anwesend, wo sich das Transplantat (wenn auch ein unbedeutender Teil des letzteren) in das Neuralrohr eingeschlossen hat. Dieser Umstand verdient m. E. besondere Achtung. Diese Tatsachen überzeugen uns, dass die Innenpflasterung der Neuralrohrshöhle und die Spongioblasten ihrer Wand (in Experimentalbedingungen) aus der Aussenschicht der Neuralplatte entstehen können (Abb. 1, *a*).

Auf kaudal liegenden Schnitten (Abb. 1, *b*), wo der Schluss der Neuralplatte noch nicht stattgefunden hat, kann man charakteristische längliche Zellen der transplantierten Aussenschicht beobachten, die sich in die aus Innenschichtzellen bestehende Masse der Neuralanlage einschliessen und deren zentralen Teil bilden (Abb. 1, *b*). Beim Zusammenstellen dieses Bildes mit dem Ergebnisse (⁴), das wir beim Unterwerfen der Aussenschicht allein des Frühgastrula-Ektoderms der induzierenden Einwirkung des Chordo-Mesoderms erzielt haben, müssen wir in Stadien der Anfangsneurulation ein vollständiges Zusammenfallen im Verhalten der Aussenschicht vermerken, sowohl in Bedingungen der Isolierung derselben von der Innenschicht als auch bei Normalentwicklung, d. h. in Gemeinschaft mit der Innenschicht.

In der Serie *R. temporaria*→*Pelobates* wurde bei 24 Embryonen glatte Anheilung beobachtet, und in allen Fällen beteiligten sich die Transplantate, die man auf dem hellfarbigen Embryo deutlich sehen konnte, äusserlich normal am Neurulationsprozess. Bei 11 Embryonen begann nach kurzer Zeit der Zerfall der Transplantate. Auf die 13 bearbeiteten Fälle zerfielen die Transplantate in 2; in 4 Fällen hielten sich und stülpten sich die Transplantate ein, ohne sich jedoch harmonisch in das Nervensystem einzuschliessen; und nur 7 Fälle können uns interessieren. Obgleich auch hier das Transplantat sich nicht immer gleich harmonisch in den Prozess eingeschlossen hat, und es hier ebenfalls einige Absterbungszeichen des Transplantats (Pigmentklümpchen u. a.) gibt, was augenscheinlich mit einem späteren Fixationstermin zusammenhängt, bieten doch diese Fälle in einer Reihe von Schnitten typische Bilder, die über das Normalverhältnis der Elemente zu urteilen erlauben. In dieser Serie wurde immer die Aussenschicht des vorderen Teils der Neuralplatte im Gebiete des Gehirns und speziell im Gebiete der Augen ersetzt.

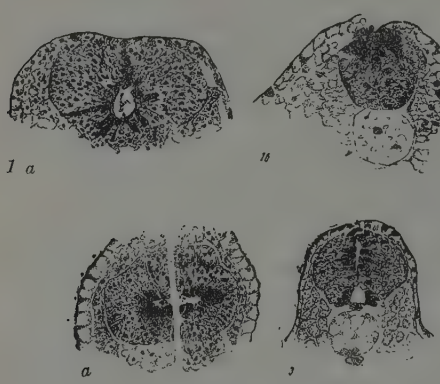

Abb. 1 (*a*, *b*), 2, 3.

In 2 Fällen nahm die transplantierte Aussenschicht teil an der Augenbildung und bildete (Abb. 2) die innere Pflasterung der Augenblasenhöhle. Was die späteren Stadien der Augenentwicklung betrifft, so ist hier bis jetzt leider noch kein Resultat erzielt, da bei späteren Fixationsterminen das Transplantat bereits zerfallen war. Jedoch bietet die Frage von der weiteren Bestimmung der Aussenschicht in der Augenbildung ein grosses Interesse, insbesondere im Zusammenhang mit den Ergebnissen der Chlopin-Schule, laut deren (5) die Pigmenthaut des Auges bei Säugetieren zu den Geweben des glialen Typus gehören soll. Insofern die Aussenschicht der Neuralplatte, laut der Ergebnisse der vorliegenden Arbeit, die Pflasterung des Neuralrohrs und die spongioblastenähnlichen Zellen seiner Wände bildet, lässt es sich fragen, ob vielleicht aus der Aussenschicht auch die Pigmenthaut des Auges gebildet wird, bzw. ob vielleicht die verschiedenen Hilfselemente des Nervensystems bei typischer Entwicklung ihre gemeinsame Quelle in der Aussenschicht haben. Die Untersuchungen der Topographie der Augenanlage (2,6) lösen diese Frage nicht: die Verfasser untersuchten nur die relative Dislokation einzelner Teile der Augenanlage auf der Fläche und dazu bei *Urodela*, denen eine so deutliche Teilung der Neuralplattenschichten fehlt.

In 5 anderen Fällen ist ein Teil des Transplantats ausserhalb des Nervensystems, d. h. im Epithel, geblieben, und der eingesunkene Teil bildet das dünne Dach des Zwischenhirns und Medulla oblongata und einen Teil der Innenpflasterung der Gehirnseitenwand. Die letztere besteht sowohl aus flachen als auch aus länglichen Zellen, die sich in das aus nichtpigmentierten Innenschichtzellen bestehende Gewebe der Wand einkeilen. Die sich einkeilenden Aussenschichtzellen haben in solchen Fällen einen länglichen Körper, der von der inneren zur äusseren Oberfläche der Gehirnwand geht. In einem Falle bildet das Transplantat nur einen Teil der inneren Gehirn-

wand. An den Stellen, wo das Transplantat mit der unterliegenden Innenschicht nicht zusammengewachsen ist, schichtet es sich, so zu sagen, von der Wand ab, und seine Zellen haben eine unbestimmte rundliche Form.

Wenn wir uns nun zu Bildern typischer Entwicklung wenden, so sehen wir, dass sie vollständig mit den Experimentalergebnissen übereinstimmen. Es wurden für die Untersuchung Embryonen von *R. temporaria* und *Bufo vulgaris* gebraucht, bei denen unser Experiment von der Natur selbst aufgestellt zu sein scheint, da bei ihnen die Aussenschicht des Ektoderms bedeutend intensiver pigmentiert ist als die Innenschicht. Auf Schnitten durch solche Embryonen (Abb. 3) sieht man, dass bei ihnen die Neuralrohrshöhle mit bedeutend intensiver pigmentierten flaschenförmigen Zellen begrenzt ist, deren dünnes Ende in die Dicke der Wand gekehrt ist. Im Gebiete der Basalplatte erreichen sie die äussere Grenze des Rohrs. In anderen Fällen, in späteren Stadien, gelingt es die dünnen Körper dieser pigmentierten Zellen bis tief in die Dicke des Neuralrohrs zu beobachten. Wenn man früher noch glauben durfte, dass die intensivere Pigmentation dieser Zellen mit der Formveränderung des Zellenkörpers während der Neurulation zusammenhängt, und dass sie nicht auf deren Abstammung aus der Aussenschicht deutet, so wird jetzt diese Voraussetzung wenig wahrsheinlich.

Die beschriebenen Beobachtungen stimmen mit der von Harrison [7] überein. Der Verfasser gibt eine folgende Beschreibung der Normalstruktur des Neuralrohrs eines Frosches im Stadium nach dessen Schluss: «The cells of the medullary cord stretch out radially, and many of them now reach from the inner to the outer limiting membrane. The nuclei are likewise elongated. Certain cells, however, occupying the peripheral zone of the wall of the tube, remain rounded and contain round nuclei. These are the first of the neuroblasts of His which will soon begin to form nerve fibers». Mit gleichem Recht könnte augenscheinlich Harrison von den länglichen Zellen sagen, dass sie «die ersten Spongioblasten» sind.

Das Übereinstimmen der Normalbilder mit den von uns beobachteten Experimentalbildern lässt keinen Zweifel, dass die stärker pigmentierten Zellen, die die Neuralrohrshöhle begrenzen und die charakteristischen spongioblastenähnlichen Zellen von deren Wänden bilden, bei typischer Entwicklung aus der Aussenschicht der Neuralplatte entstehen. Es bleibt aufzuklären, ob sich aus der Aussenschicht der Neuralplatte nicht auch noch andere Elemente in die Masse des Neuralrohrs ausscheiden, abgesehen von den «Spongioblasten». Was die übrigen nichtpigmentierten Zellen betrifft, die den Hauptteil des Neuralrohrs bilden und von Harrison als erste Neuroblasten bezeichnet werden, entstehen sie aus der Innenschicht.

Auf diese Weise haben wir bei *Anura* schon im Neurulastadium eine morphologisch abgesonderte Komponente der Neuralplatte, und zwar deren Aussenschicht, die bei typischer Entwicklung jedenfalls einen Teil der Stützelemente des Gehirns bildet. Das öffnet uns den Weg zum Studium der Eigenschaften der erwähnten Komponenten und erlaubt an das Experimentalstudium einer von den schwierigsten Fragen der Neurogenesis heranzutreten—der Frage nach der Abstammung, Determination und den Wandlungen der Elemente der glialen und der neuroblastischen Reihe in den frühesten Entwicklungsstadien des Nervensystems.

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ZITIERTE LITERATUR

[1] Т. Детлаф, Тр. Ин-та экспер. морфогенеза Моск. ун-та, VI (1938). [2] E. Manchot, Roux' Arch., **116** (1929). [3] W. His, Arch. f. Anat. u. Phys., H. I, II (1899). [4] T. Dettlaff, C. R. Acad. Sci. URSS, No. 7 (1940). [5] J. A. Vinnikov, ibid., XX, 211 (1938). [6] M. W. Woerdeman, Roux'Arch., **116** (1929). [7] R. Harrison, J. of Comp. Neurol., **37**, No. 1 (1924).

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PARASITOLOGY

INVESTIGATION OF THE LIFE CYCLE OF *BUNODERA LUCIOPERCAE* MÜLL. *(TREMATODES DIGENEA)*

By M. S. KOMAROVA

(Communicated by I. I. Schmalhausen, Member of the Academy, 30.I.1941)

According to literary data, longevity of helminths ranges from a few weeks to several years. For example, Montgomerie (1931) reports that *Fasciola hepatica* lives in rabbits over 3 years, and still longer in other animals. According to Sandground (1936), *Gastrodiscoides aegyptiacus*, which is parasitic in zebra, lives in its host for 9 years, while the liver trematode, *Clonorchis sinensis*, parasitic in man, reaches the age of 25 years, and *Schistosoma haematobium* even up to 28 years.

The aim of the present note is to elucidate the life cycle of the trematode *Bunodera luciopercae*, a common parasite in the intestine of fishes of the *Percidae* family. The invasion intensity of Dniepr fishes with this trematode ranges from 1 to 40 parasites per individual, though in one case a single fish was found to harbour 244 parasites.

In the course of treatment of the material collected according to seasons, we succeeded in revealing the following most interesting details of the life ycle of *Bunodera luciopercae.*

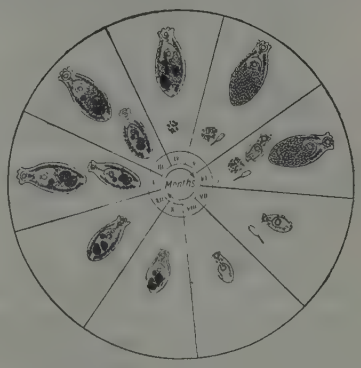
Month	III	IV	V	VI	VII	VIII	X	XII	I
Number of fishes anatomized	5	10	8	22	18	21	15	10	15
% of invasion with mature forms	80	70	62.5	59	0	0	0	0	13.3
% of invasion with immature forms	20	0	0	22.7	44.4	52.3	53.3	60	53.3

The table shows the monthly distribution of this parasite in perch. As may be seen from this table, both mature and immature forms are found in summer (June). The percentage of invasion with mature forms was 59, while immature forms were present in 22.7% of cases. At this time mature forms have the shape of a bag filled with eggs up to the ventral sucker (Fig. 1). The size of mature forms at this period is considerably smaller than that of mature ones; they contain no gonads, while the digestive and the secretory systems are well developed.

In July and August the rate of invasion varies from 44.4 to 52.3%. At this time none but immature *Bunodera luciopercae* are met with. The gonads, however, begin to develop.

In autumn (October) the ratio of invasion equals 53.3%. The parasites still remain immature, as it is the case in July and August. They have considerably grown within this period and considerably exceed in size the forms observed in summer. Their ovaries and testicles become enormous; the vitellar glands are at the stage of development, no eggs are still produced.

In winter (December) the invasion ratio is about at the same level (60%). The worms have advanced in their development—the gonads are ripe, though no eggs are still being produced. The size of the trematodes found during this period exceeds that of immature forms collected in summer or autumn. In January 2 individuals (13.3%) containing a few eggs (from 1 to 13) were found along with trematodes (53.3%) containing no eggs.



Cycle scheme of *Bunodera luciopercae*.

In spring (March) the worms begin producing eggs, a large number of which is produced within a rather short time. However, along with trematodes producing eggs we have found one individual of *B. luciopercae*, containing no eggs at all.

In April and May all the parasites without exception are filled with eggs, the invasion ratio varying at this time from 62.5 to 70%.

An analysis of the data on the seasonal invas on of the perch with *Bunodera luciopercae* enabled us to reproduce a compl ete scheme of the life cycle of this parasite. From these data it follows that its life cycle comprises one year. The worms begin producing eggs by the end of winter, though single individuals start ovulation as early as in January. In April, May and June the trematodes lay eggs and perish. During this period proceeds the development of parthenogenetic generations in intermediate hosts. Invasion of fishes with new generation of the parasite begins in summer; this is why all the worms found in fishes during summer (July, August) prove to be immature. Further development of the trematodes which will start ovulation in the spring of the next year, takes place during autumn and winter.

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PALEONTOLOGY

GENUS *PRODUCTUS* SOW. s. l. IN THE UPPER CARBONIFEROUS OF THE DONETZ BASIN

By B. LICHAREW

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The genus *Productus* s. l. occurs in great abundance in the Upper Carboniferous of the Donetz basin. The author has made a monographic study of its representatives from the collections of the All-Union Geological and Prospecting Institute obtained from the series Isayevo (C_3^2, according to the former scheme of the Donetz geologists), Avilov (C_3^3) and Markov. Under the name of the latter I have separated the lower part of the so-called Araucarite series (with limestones P_1—P_5). Whereas from the gypsum-dolomite series representatives of the genus concerned were described by N. Yakovlev as far back as in 1912, those from the above-mentioned series have not been studied until late. In one of N. Lebedev's papers are listed about 20 species of *Productus*, encountered in the Isayevo and Avilov series, but I doubt strongly the correctness of his determination (mention is made of the Lower Carboniferous *Pr. semireticulatus* Mart., *Pr. anomalus* Keys., *Pr. inflatus* McChesn. and the Permian *Pr. artiensis* Tschern., *Pr. gratiosus* Waag., which I failed to reveal in the material at my disposal. Lists made up in 1897 by L. Lutugin and Th. Tchernyshew are, naturally, quite out of date.

I was able to ascertain that up to 90 forms are present in the above-mentioned horizons and that they include representatives of the subgenera: *Avonia* (which I have united with *Krotowia*)—8 forms, *Pustula* (united with *Echinoconchus*)—7 forms, *Buxtonia* (united with *Juresania*)—9 forms, *Productus* s. s. (alongside of these I am placing also *Linoproductus*, *Cancrinella*, *Dictyoclostus* as groups)—48 forms, *Urushtenia*—1 form and *Marginifera*—17 forms. Of these forms 41 are known from the Isayevo, 58 from the Avilov and, lastly, 31 from the Markov series.

Most abundantly are represented *Productus* s. s. and, particularly, the group *Pr. semireticulatus*. The most common species for the Upper Carboniferous of the Donetz basin is *Productus donetzianus* Lich., appearing already in the Middle Carboniferous and particularly developed in its typical in the limestone N_1. In the higher horizons specimens of the latter occur in greatly reduced numbers, while at the same time there appear several varieties of this basic form, differing from it in relatively minor characters. In the Avilov series one of these mutations (mut. *crassiornata* mut. n.) attains its largest size. It should be noted that representatives of *Pr. donetzianus* occur, no doubt, also beyond the limits of the Donetz basin, however,

in some of the works by foreign authors they were erroneously described under the name of *Pr. gruenewaldti* Krot., from which they are readily distinguishable by more sharply pronounced radial sculpture in the anterior portion of the shell and by the presence of an isolated trail.

Among *Avonia* most frequently appear *Pr.* (*Avonia*) *echidniformis* Grab. et Chao and *Pr.* (*Avonia*) *krutoyensis* Sem., the former being more characteristic of the Isayevo and the latter of the Avilov series. Among *Pustula* highest development attain *Pr.* (*Pustula*) *neopunctatus* sp. n., differing from *Pr.* (*Pustula*) *punctatus* Mart. in the presence of two diverging crests running from the beak on the inner side of the ventral valve, partly *Pr.* (*Pustula*) *elegans* MacCoy (with its variety var. *fasciata* Kut.); *Pr. sterlitamakensis* Step. is rare. Subgenus *Buxtonia* is represented by 9 forms; they include one of the largest Donetz species nf *Productus*—*Pr.* (*Buxtonia*) *kalitvaensis* Lich.; to the latter stands close *Pr.* (*Buxtonia*) *jernovoensis* sp. n. (with sinus), showing a wider vertical development. Typical *Pr.* (*Buxtonia*) *subpunctatus* Nikit. are developed in the Avilov series, but var. *shurabensis* Lich. appears already in the Middle Carboniferous; var. *araucaritica* Lich. with coarser ribbing is met with beginning from limestone O_4 and is strongly developed in P_1. Among *Productus* s. s. fine-ribbed forms (*Linoproductus*) are usually represented by a small number of specimens; the majority of large forms of the latter are referred by the author to different varieties *Pr. cora* d'Orb.—var. *lineata* Waag., var. *neffedievi* Ivan. (non Vern. ?), var. *dorotheevi* Fred., var. *extensa* var. n., var. *ovalis* Ivan.; more frequently occur small forms (*Cancrinella* auct.); among the last-mentioned ones some new species have been established. The semireticulate group includes, besides the above-mentioned *Pr. donetzianus* and its mutations, still a number of others, such as: *Pr. dortoni* King., *Pr. houyuensis* Ozaci and a few new species*. *Pr. gruenewaldti* Krot. is represented mainly by its variety var. *samarensis* Stuck.; the holotype of the latter, subjected to supplementary treatment by the author, appeared as a more elongated form than the one figured in the monograph by A. Stuckenberg (1905, table VI, fig. 9). Well represented appears to be *Pr. gratiodentalis* Garb. with its varieties var. *koluberica* Ivan. and v. *gratiosiformis* v. n., the latter lacking the rib which marks off the auricle. An original new small form presents *Pr. proprius* sp. n. carrying a median fold on the ventral valve, instead of a sinus. Some interest from the biostratigraphic point of view belongs to the presence (true enough, of a single specimen) of *Productus incisus* Schellw. in the limestone N_1, in so far as until now this species was reported but from the Permian deposits. Quite rich development show representatives of *Marginifera*, up to 17 forms belonging to 6 species. Their determination, like that of representatives of the group *Pr. donetzianus* Lich., presents great difficulties for the taxonomist, the species available showing considerable variation of characters and monotony in the basic type of structure; when there are only single specimens present, their accurate determination becomes, as a rule, practically impossible. Particularly wide development show *Pr.* (*Marginifera*) *timanensis* nom. n. ** with its mutations. Another species, just as widely distributed and polymorphic in the Upper Carboniferous of the Donetz basin, is *Pr.* (*Marginifera*) *capaciformis* sp. n., identical with *M. typica* var. *borealis* Ivan. The last-mentioned form cannot be regarded as a variety

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* *Pr. inca* d'Orb. and *Pr. hermosanus* Girty, previously reported from the Carboniferous of the Donetz basin, are missing here.

** The new name *timanensis* is substituted by the author for the old one—*timanica* proposed by Tschernyschew, since the latter had already been applied for the genus *Productus* s. l.: for the same reason I suggest to change *Pr. uralicus* Tschernyschew, 1902 (non *Marginifera uralica* Tschernyschew, 1889) to *Pr. uralensis* nom. n.

of the Indian *M. typica* Waagen; and to retain the name *borealis* as a specific name does not seem to be possible, inasmuch as it is already preoccupied in the genus *Productus*.

Considering the vertical distribution of the forms which have been studied, note should be taken first of some of the characteristic features of the paleogeography of the Upper Carboniferous of the Donetz basin. The lithological character of the local sediments and the distribution of fossils within them testify that the marine fauna must have had many times emigrated from this basin and returned back again from the region where marine conditions have been more persistent. Therefore within the confines of the basin proper we fail to observe series of forms which would follow in uninterrupted succession as links of one evolutionary process. The study of *Productus* shows that under such conditions, too, the majority of species were quite conservative and passed without any particular changes through the entire thickness under investigation. Cases were reported when a certain form occurring in the basin in the lowermost parts of the Upper Carboniferous (limestone N_1) reappears there only after a considerable interval (in the gypsum-dolomite beds). Similar cases can hardly be explained by the incompleteness of the collections alone. Such conservatism of the representatives of the genus *Productus*, while their specific characters are showing strong variation, impairs greatly their biostratigraphic value. Unfortunately, I lack at the present any data which would speak for or against the presence in the Upper Carboniferous of the forms recorded by me, therefore the picture of the distribution of these species in vertical direction seems to be somewhat incomplete at present.

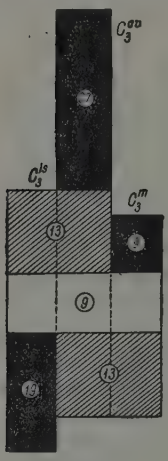

Fig. 1.

In generalizing the data obtained, they are represented graphically (Fig. 1) so as to have the area in black correspond to the number of forms restricted to one given series, those shaded—to forms passing through two adjacent series, and the blank ones—to all of the three series. Many of the polymorphic species present in their vertical range a picture similar to the one described above for *Pr. donetzianus* Lich., the basic form continues to exist for a length of time decreasing in number and yielding several mutations closely allied to it. Thus, *Pr.* (*Marginifera*) *timanensis* nom. n. extends to the limestone O_4, being abundantly represented but in the Isayevo series; in the Avilov series make appearance its mutations var. *pusilla* Schellw., var. *pusilliformis* var. n. and var. *laticostata* var. n. The prolonged existence of the basic form can be explained not only by the restoration of the former physical-geographical conditions at the time of reimmigration of marine forms into the area of the basin, but also by the relatively short geological span corresponding to the deposition of the three above-mentioned series of the Upper Carboniferous.

Attempts at correlation of the Upper Carboniferous of the Donetz basin with synchronous deposits in other regions on the basis of *Productus* fauna have so far failed to produce any satisfactory results. It is striking, for instance, that the number of Middle Carboniferous forms of the Moscow basin has proved about alike for all of the three Donetz series, and besides quite appreciable (25%, 20%, 20%). The number of Isayevo forms is approximately the same in the Middle Carboniferous, Teguliferina and Omphalotrochus horizons, and the number of those of Avilov even the largest in the Middle Car-

boniferous of the Moscow basin. Besides, there are considerable differences in the development of various subgenera *Productus* in the two basins, in particular, as far as *Avonia* and *P. donetzianus* are concerned, though, possibly, the coarse-ribbed mutation of the latter (mut. *crassiornata* Lich.) does occur in the osc ow basin. The total number of forms common to both basins equals 23.

The Don fauna stands somewhat closer to the Donetz one than does the Moscow fauna, this being particularly manifest in the development of the group *Pr. semireticulatus* s. l. in the Upper Carboniferous of the Don region. This similarity is bound to increase after a revision of *Productus* from the Don Carboniferous, which was not accurately enough described by S. Semichatova (for example, *Pr. inca*, *Pr. pseudopratenianus*). As to the fauna from the *Pseudoschwagerina* horizon of the Ural region, there is not much resemblance between *Productus* met here and in the Donetz basin.

Interesting correlation could be obtained, no doubt, on comparing the Donetz *Productus* to those from the Auernig beds of the Carnic Alps and the Taiyuan series of N. China. But the material from the Carnic Alps is in a very poor state of preservation, and it is impossible to draw any conclusions without being personally acquainted with it. However, as far as the Chinese fauna is concerned, it should be remembered that in the notable monograph by Ozaci the Middle Carboniferous forms are not separated out from the Upper Carboniferous ones.

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REFERENCES

[1] А. Штукенберг, Тр. Геол. ком., нов. сер., вып. 23 (1905).

Translated by T. Sachs.

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PALEONTOLOGY

ON SOME MIDDLE CARBONIFEROUS SPECIES OF *FUSULINIDAE* OF THE MOSCOW DEPRESSION

By S. E. ROZOVSKAYA

(Communicated by A. A. Borissiak, Member of the Academy, 10.II.1941)

To meet geological requirements, the author deems it necessary to publish the results of preliminary work on two species of *Fusulinidae* from the Middle Carboniferous of the Moscow depression, i. e. *Fusulina pancouensis* (Lee) and *Fusulina innae* sp. nov.

These species are likely to be of great value in the solution of biostratigraphical problems and correlation of deposits of the Podolsk horizon of the Russian platform.

Fusulina pancouensis was first found and described from the Middle Carboniferous of China (Penci series). In the USSR vast number of *Fusulina pancouensis* have been met only in the upper half of the Podolsk horizon (C_{II}^3) in a bedpack of limestones of small thickness. Associated with it have been met representatives of the groups *Fusulinella bocki* Moeller, *Fus. pseudobocki* Lee et Chen, *Fusulina minima* Schellwien, *Staffella sphaeroidea* (Ehrenberg) etc.

The author has had at her disposal material derived from the following points of the Moscow depression: villages Karabcheievo and Maleievo on the Oka river, Staraya Rusa on the Moskva river, Dubeiki, quarry No. 1, 302—305 m deep, and Neieitzino, quarry No. 2, at a depth of 149 m. This material has been presented to the author by D. Rauzer-Chernoussova and by the micropaleontologist N. D. Gryzlova from the Moskow Oil Trust.

Being a form of a rather limited vertical range, *Fusulina pancouensis* assumes great biostratigraphical value and may become a guide-form for the deposits of the Podolsk horizon of the Russian platform.

Analysis of material on hand warrants the assumption that *Fusulina pancouensis* (Lee) and *Fusulina innae* sp. nov. [ex gr. *elegans* ([4])] are genetically closely interrelated. These two species manifest quite vividly that there are certain regularities underlying the development of individual characters which have served as a basis for Rauzer-Chernoussova to trace the phylogeny of the whole fusulinid family ([2], [3]).

Fusulina innae sp. nov. makes its appearance in the lower half of the Podolsk horizon and undergoes further development throughout its entire range. In the upper half of the horizon this form yields a side-branch—*Fusulina pancouensis*, evidently expiring here because of peculiar specialization of its characters. These characters are: strongly elongated shell along the axis of coiling already in the most youthful whorls, intense septal folding and axial part compact and strongly developed. *Fusulina pancouensis* (Lee) exhibits the same specialization of characters as do the terminal representatives of some other phylogenetic branches of the family *Fusulinidae*, e. g. *Quasifusulina*, the terminal branch of the genus *Fusulina*, and *Parafusulina—>Polydiexodina*, which are the terminal branches

in the evolution of the family *Fusulinidae*, characterized likewise by a strongly elongated shell, intense folding, volutions little increasing in height and compact axial part sharply pronounced.

The suggestion that *Fusulina pancouensis* (Lee) and *Fusulina innae* sp. nov. are genetically closely related to each other gives rise to no particular doubt, owing to a number of quite specific transitional characters, such as: shape of whorls, sharp differentiation of theca with formation of diaphanotheca and quite massive and compact axial part, so not characteristic of the whole genus *Fusulina*, appearing already in *Fusulina innae*.

Fusulina innae sp. nov. (Fig. 1). Description. Shell elongated-fusiform, slightly inflated medially with gradually narrowing and obtusely pointed ends. Shell quite appreciably elongated already beginning from the second volution. Ratio $L : D$ in third volution equal to 2.5—3.0, in the outer volutions the ratio varies from 2.9 to 4.17.

Fig. 1. *Fusulina innae*, sp. nov. Axial section of holotype, Moscow basin, left shore Moscow river, Staraya Rusa, lower half of Podolsk horizon, specimen 50 (×13).

Shell of medium size: $L = 4.08 — 5.5$ mm, $D = 1.1 — 1.84$ mm; number of volutions 5—6, more often 6. Initial chamber 190—230, and often 190 μ. Whorls coiling very uniformly. Diameter of fourth volution measuring of 0.7—1.13 mm; more frequently occurs form with diameter equal to 0.9—1.0 mm. Diameter of volutions in the specimens measuring (in mm):

Specimen No.	Initial chamber	1	2	3	4	5	5.5	6
50	0.23	0.40	0.58	0.82	1.13	1.37	1.85	—
51	0.19	0.30	0.57	0.69	0.73	1.08	—	1.44

Theca with a distinct diaphanotheca, moderately thick. In the outer whorls it attains a thickness of 35—45 μ, in the inner ones 25—35 μ.

Septa fairly thick, somewhat thinner than the theca, quite strongly folded. Folds forming regular, not thickly set loops, fairly lofty, rounded and occasionally subsquare in shape, not traceable along the axis in the inner volutions because of the massive and compact axial zone.

Aperture regularly situated, of medium height, narrow in the inner volutions, gradually expanding in the outer ones. Chomata distinct on 4—5 whorls; axial part considerably compact; axial zone well developed on 4—5 whorls.

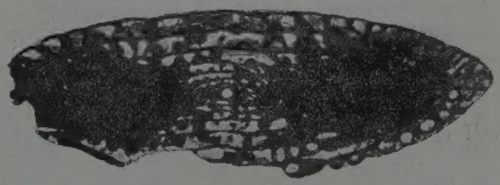

Fig. 2. *Fusulina pancouensis* (Lee), axial section of typical specimen, Oka-Zna bank, Oka river, Maleievo, upper half of Podolsk horizon, specimen 52 (× 13).

In regular and intense folding, structure of theca and form of spiral *Fusulina innae* sp. nov. shows great affinity with *Fusulina elegans* Raus. From the latter our species differs by compact axial part and elongated form of shell through

all the whorls. To *Fusulina pancouensis* (Lee) the form under description comes near in the structure of the theca, elongated form of the shell and presence of compact axial part, while differing from it in the form of the spiral and more regular folding.

Locality and Age. Moscow depression. Podolsk horizon (C^3_{II}). Holotype—specimen No. 50 (Fig. 1).

Fusulina pancouensis (Lee) (Fig. 2). 1927. *Girtyina pancouensis* Lee. *Fusulinidae* of N. China. Palaeont. Sinica, ser. B, vol. 4, p. 30—32, pl. V, fig. 3—5. Shell of sub-cylindrical form, sometimes curved in the axial zone. Umbilical ends pointed and sometimes blunted and fairly rounded. $L : D$ varies from 3 to 4, the ratio becoming fixed already from the second-third volution. Surface of shell shows sinous septal grooves. Shell dimensions vary: L measuring 5.5—7.0 mm, $D = 1.44$—2.47 mm. Number of volutions 5—7.5, more frequently 6.5. Spiral in inner volutions quite narrow. In 3—4th volution spiral coiling quite slowly, whereas in the successive volutions coiling proceeds more rapidly, yet uniformly. Diameter of fourth volution usually measuring 0.8—0.9 mm. Diameter of volutions in the specimens are as follows (in mm):

Specimen No.	Initial chamber	1	2	3	4	5	6	6.5
52	0.16	0.25	0.40	0.58	0.81	1.21	1.80	1.98
53	0.21	0.32	0.38	0.69	0.87	1.21	1.53	—

Initial chamber medium-sized, with diameter usually equal to 160—220μ. Theca very thin with distinct broad diaphanotheca of the fusulinid type. On very rare occasions outer volution reveals faint traces of alveolae. In the internal volutions thickness of theca reaches 15—19 μ, in external ones from 25 to 35 μ.

Septa quite thin; regularly folded throughout the entire length of volutions. Folding moderate to quite intensive. Loops formed by folding, high, filling three quarters of the lumen of chambers, angular or rounded in shape. Septa forming alveolar network in axial ends.

Supplementary deposits, assuming the aspect of massive thickenings, extend throughout the entire length of the axial zone. Chomata clearly pronounced in 4—5 volutions. Aperture quite narrow in inner volutions, broadening abruptly toward the outer ones.

The specimens treated by the author can be wholly identified with the typical *Fusulina pancouensis* described by Lee from the Middle Carboniferous deposits of China, but here have been met forms with a greater number of volutions and somewhat more rapidly expanding spiral in the external 2—3 volutions. In the character of folding and massive and compact axial part it has close affinity with *Quasifusulina longissima* (Moeller), however, appreciably differing by the presence of chomata and diaphanotheca.

Locality and Age. Moscow basin and Oka-Zna bank. Upper half of Podolsk horizon (C^3_{II}).

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10.II.1941.

REFERENCES

[1] Lee, Palaeont. Sinica, ser. B, 4, No. 4 (1927). [2] Д. М. Раузер-Черноусова, Определитель фораминифер нефтеносных районов СССР, ч. 1 (1937). [3] Д. М. Раузер-Черноусова, П. М. Беляев и Е. А. Рейтлингер, Тр. НГРИ, нов. сер., вып. 7 (1940). [4] S. E. Rozovskaya, C. R. Acad. Sci. URSS, XXVIII, No. 5 (1940).

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